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163

INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

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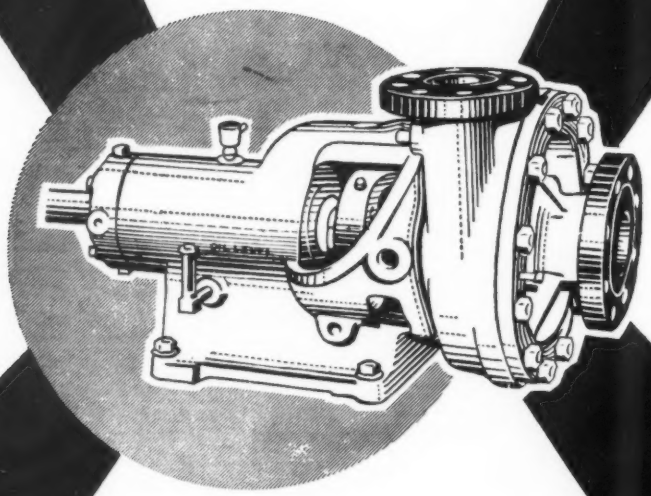

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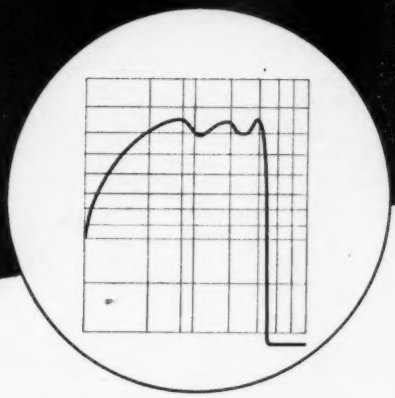

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find always an important place in the development, manufacturing and testing of communication networks, because the measuring values of level, loss, impedance etc. as a function of frequency are reproduced instantaneously on the Cathode Ray Tube. Along with other instruments it is possible to localise the faults on transmission lines and to take routine measurements without interrupting the operation of multi-channel carrier telephone circuits.

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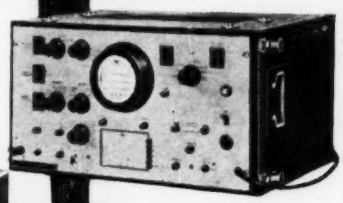

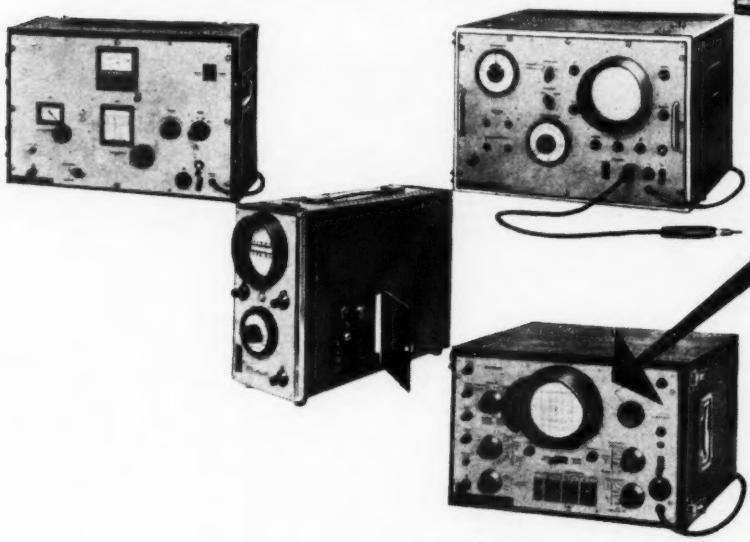

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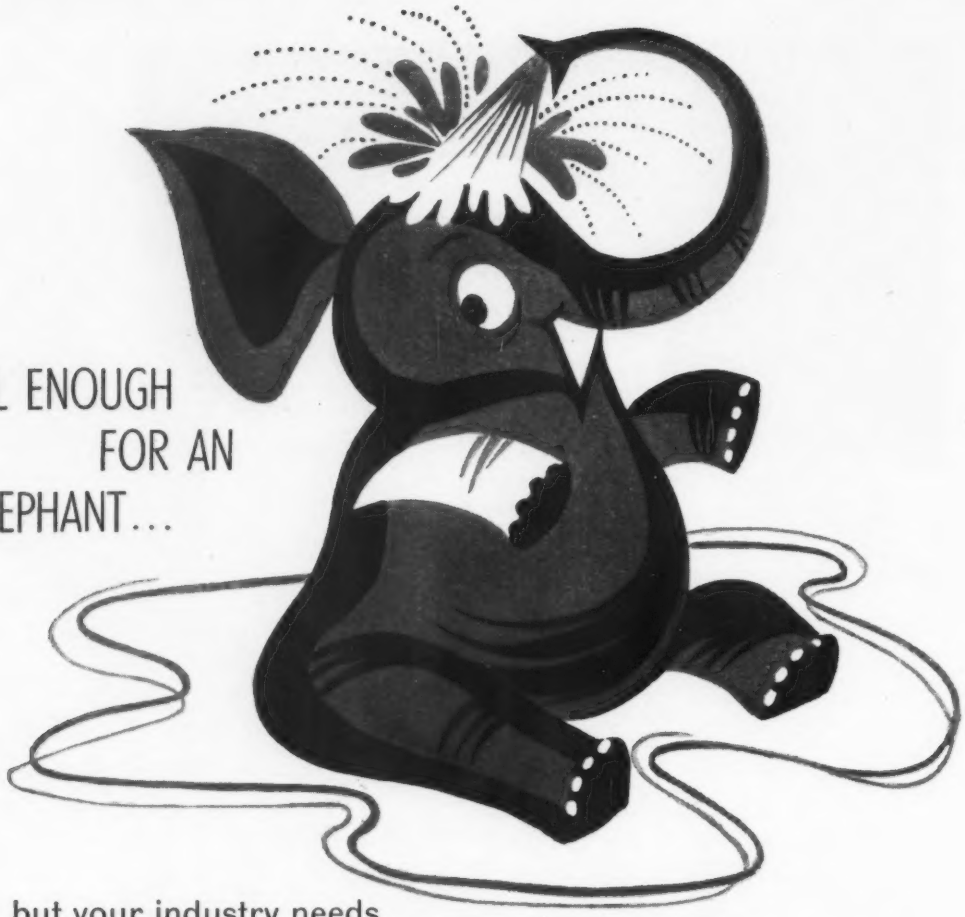

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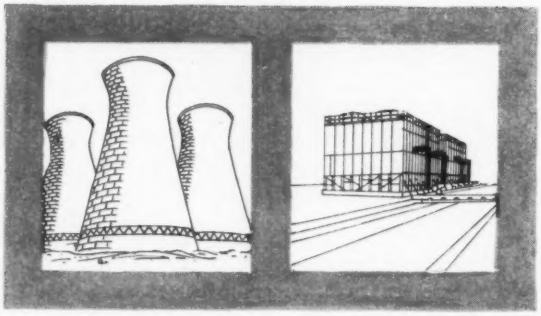

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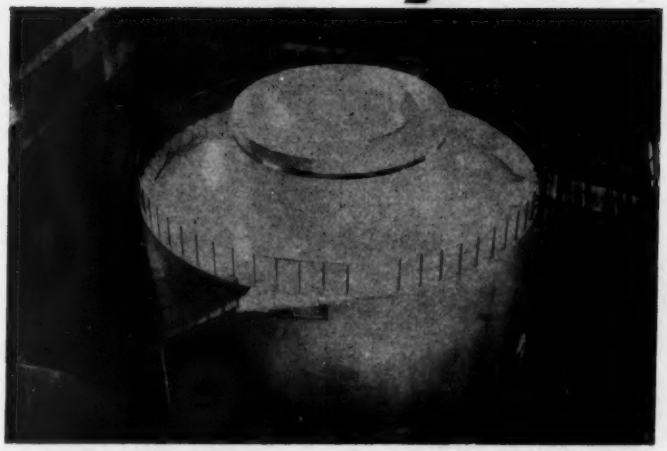

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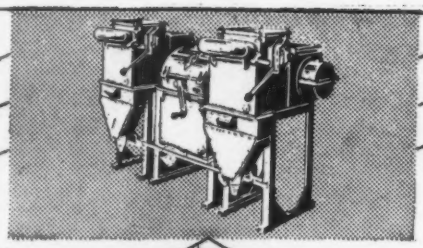

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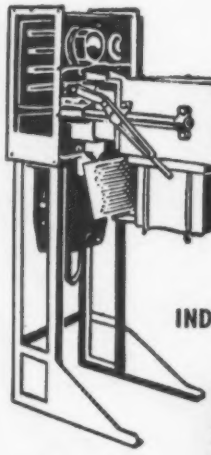
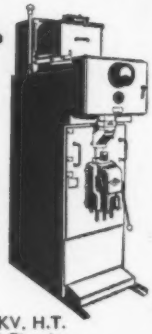
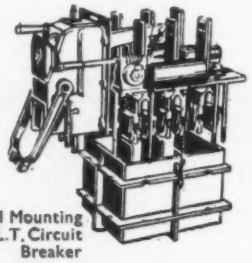


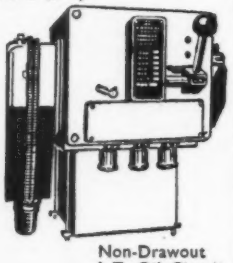
Horizontal L.T. Drawout Circuit Breaker



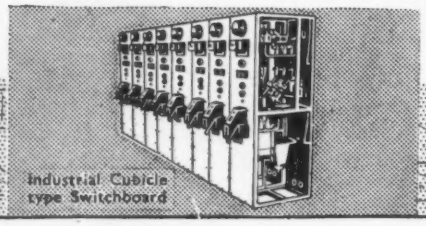
11 KV. H.T. Oil Circuit Breaker



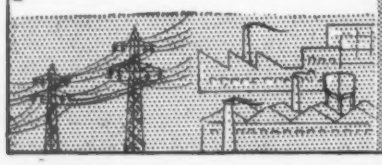
Panel Mounting L.T. Circuit Breaker

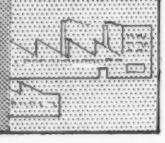


Non-Drawout L.T. Oil Circuit Breaker

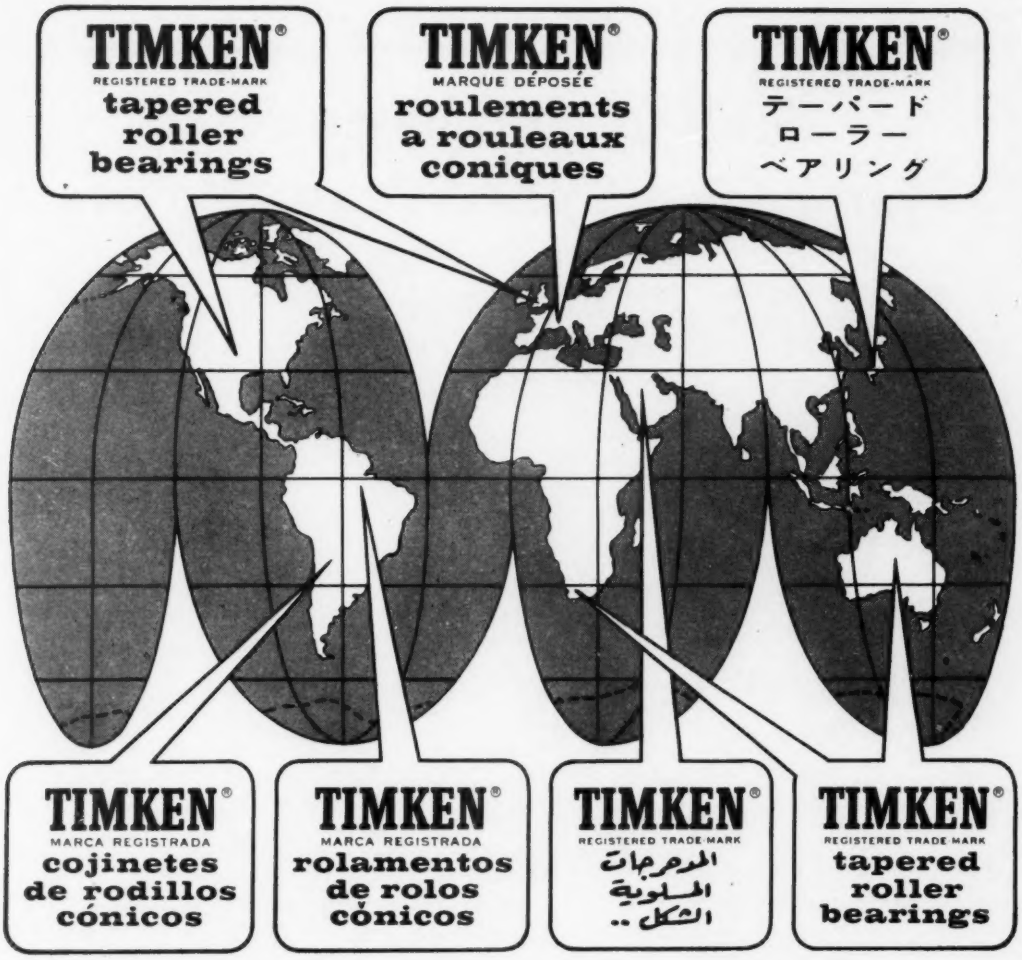


Industrial Cubicle type Switchboard





IA-50



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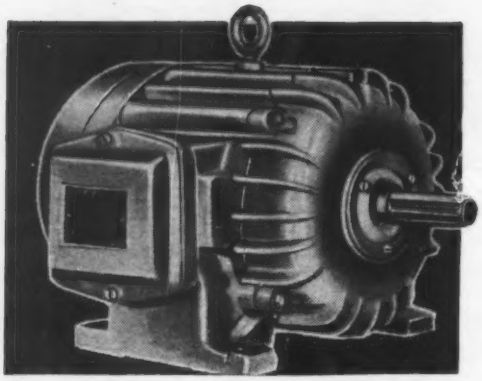

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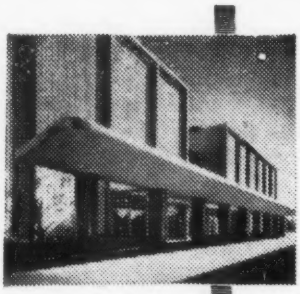

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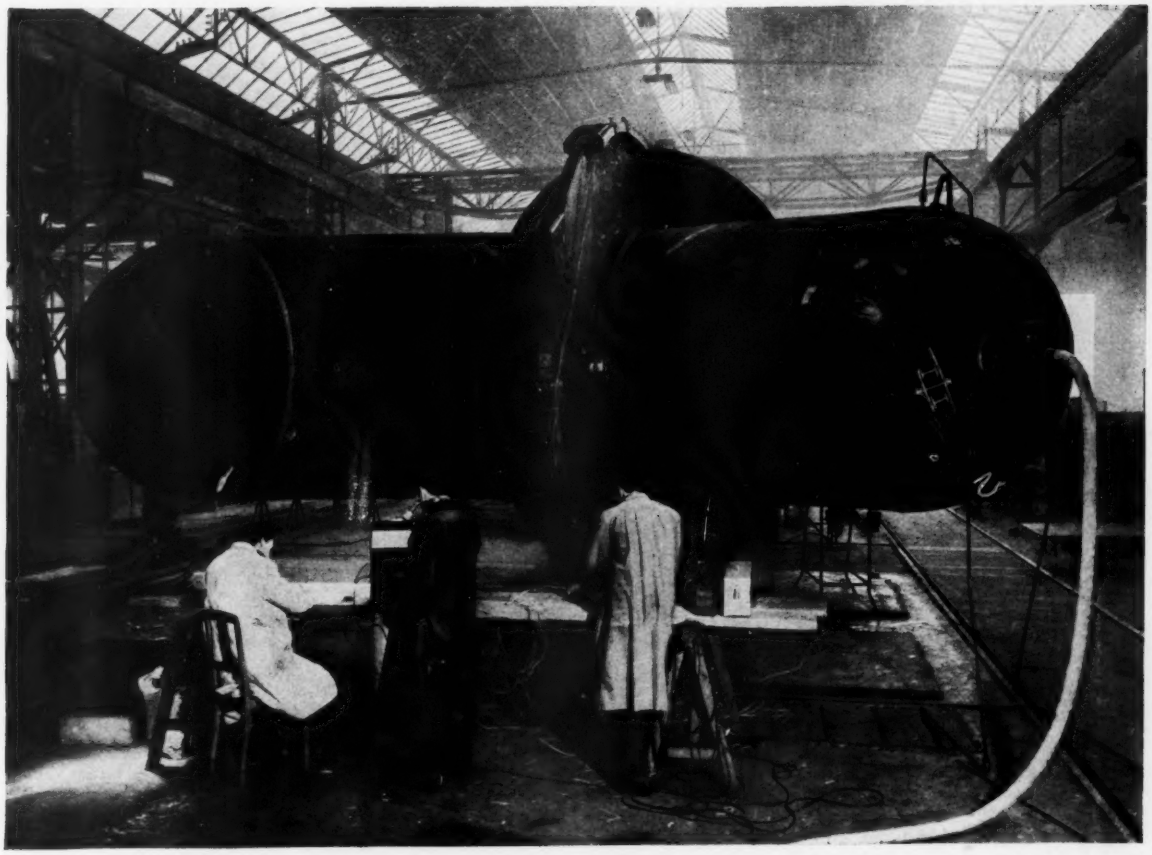

Pressure test and Electric Strain Measuring carried out on the manifold of the KOYNA POWER STATION (Maharashtra State). Test pressure 1420 psi. Diameters 8'6"/2×6'. Thickness 1" 27/32 and 1" 37/64. Weight 40·5 tons.

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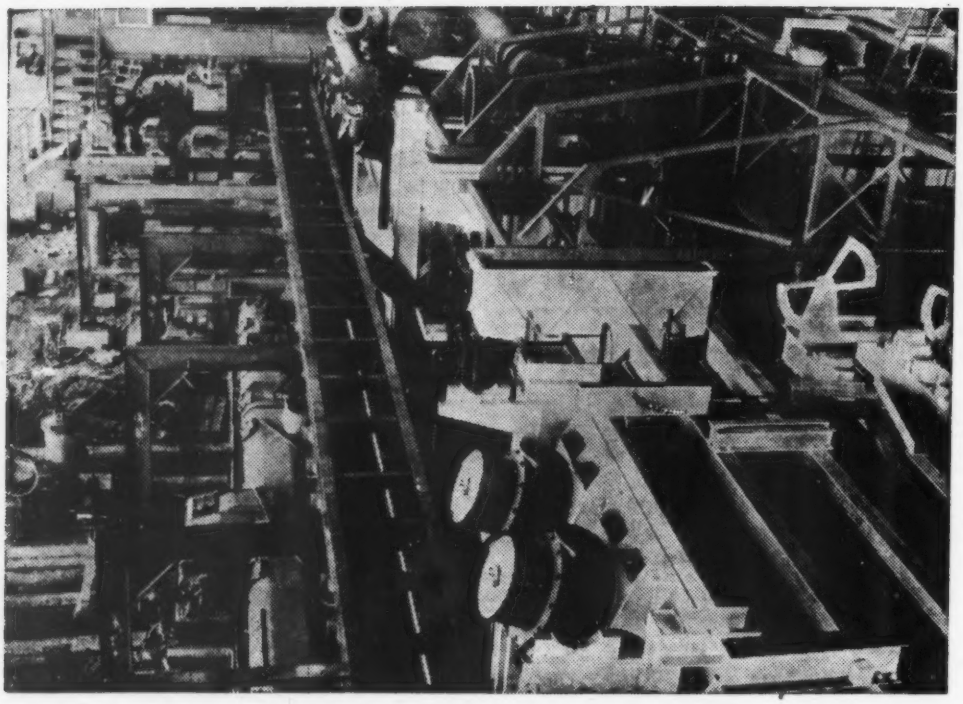

Medium Section Mill—Bloom reheating furnace and Mill run-in table

Construction and operation proceed side by side at Durgapur Steelworks

ISCON's Medium Section and Merchant Mills—the final unit of the Rolling Mills Plant—are now well on the way towards completion. Three Mills were commissioned earlier last year and are in operation. The two new Mills will make a considerable addition to Durgapur's productive range.

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HITACHI

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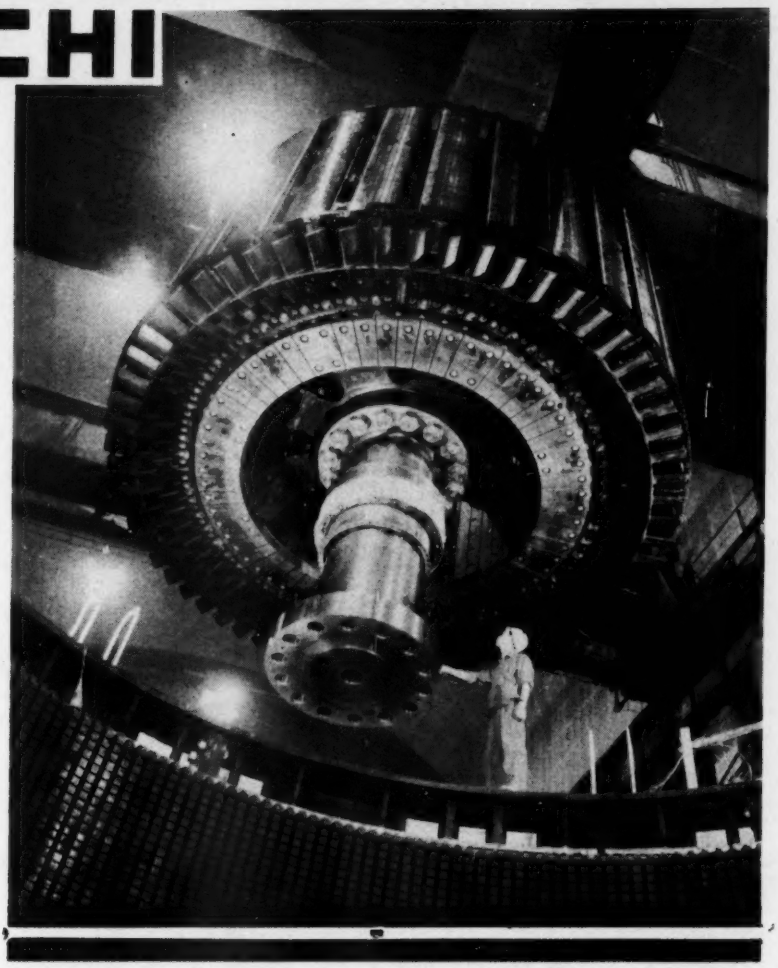

Hitachi has recently completed two 137,500 kw/125,000 kVA hydraulic turbines and generators for the Miboro Power Station in Central Japan. The turbine is of the vertical-shaft Francis type, and specified for a speed of 225 rpm, a maximum effective head of 200 m and 76.6 cu.m/sec water flow, making it one of the largest units of its kind in the world. Its runner has a maximum diameter of 3.7 m and the main shaft a diameter of 95 cm. The spiral casing, which was constructed in 13 sections to facilitate transportation to the site, has an inlet diameter of 3.35 m and an outer diameter of 11.2 m.

The generator presents a high-torsoed appearance, having been so designed in consideration of the comparatively high speed. Since the generator was designed for a rated voltage of 16,500 volts and, in this respect, represents the first such attempt in Japan, particular care was taken in the corona-shielding and impulse resistance of the stator winding. The generator is rated at 60 cycles, 225 rpm and 0.9 power factor but is also capable of operating at 50 cycles, 187.5 rpm and 1.0 power factor.

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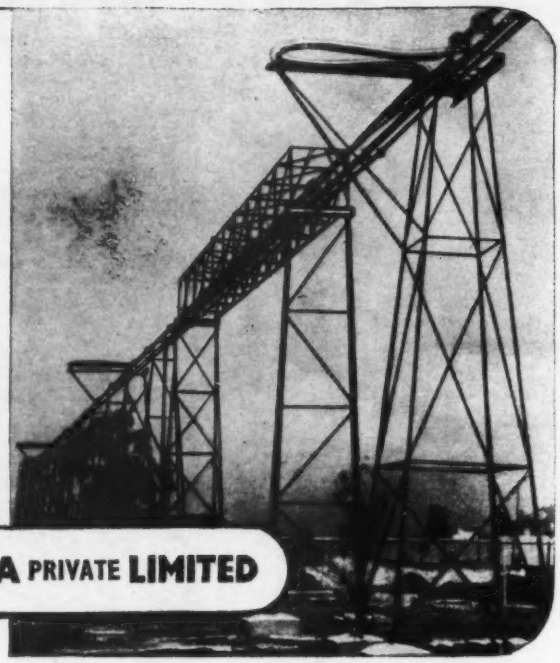

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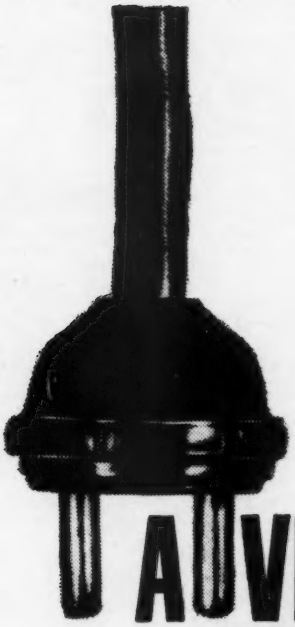
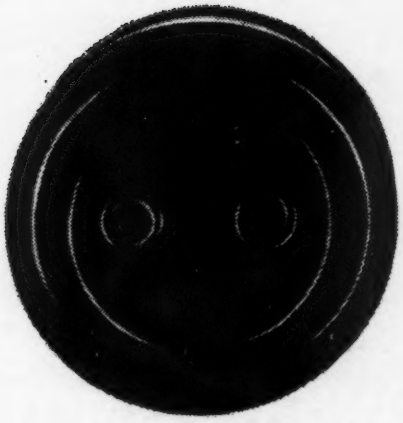


A VITAL LINK



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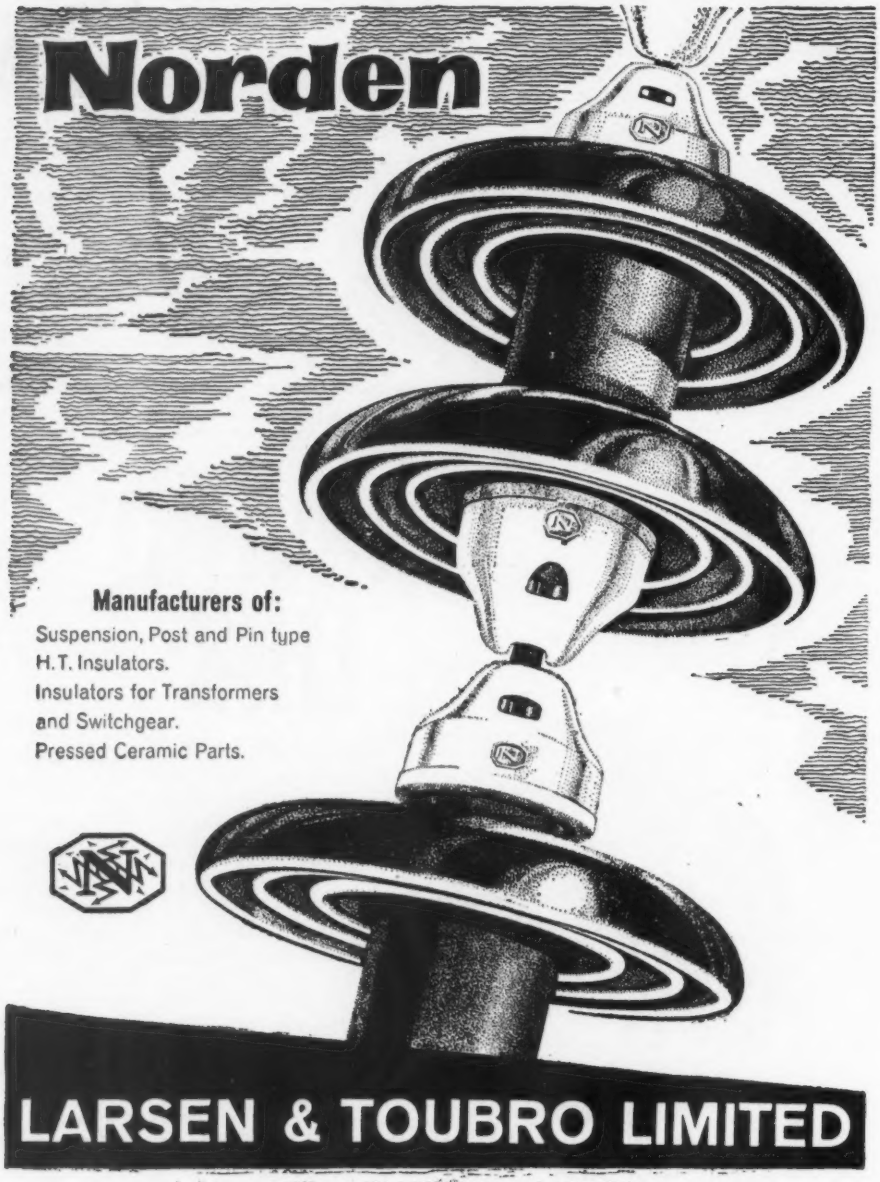

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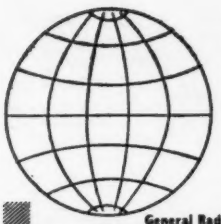

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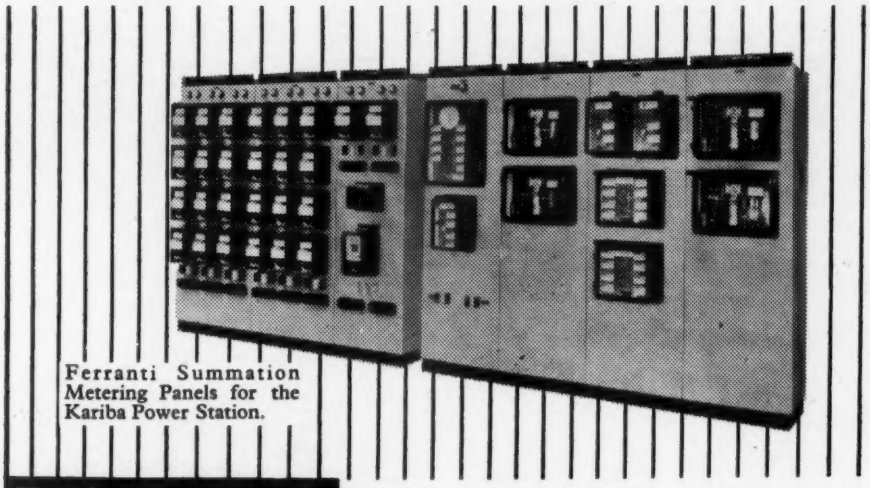

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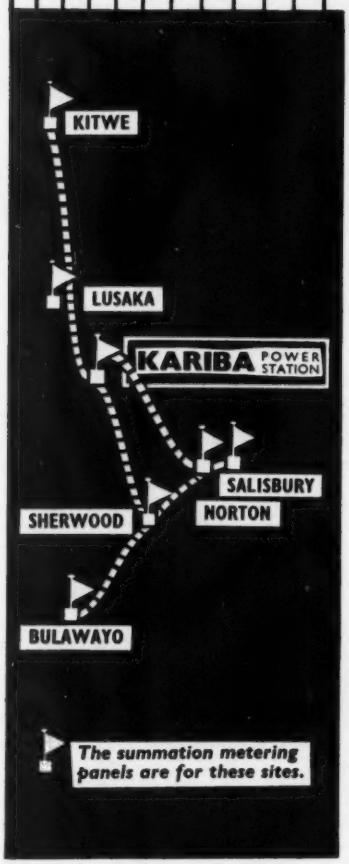

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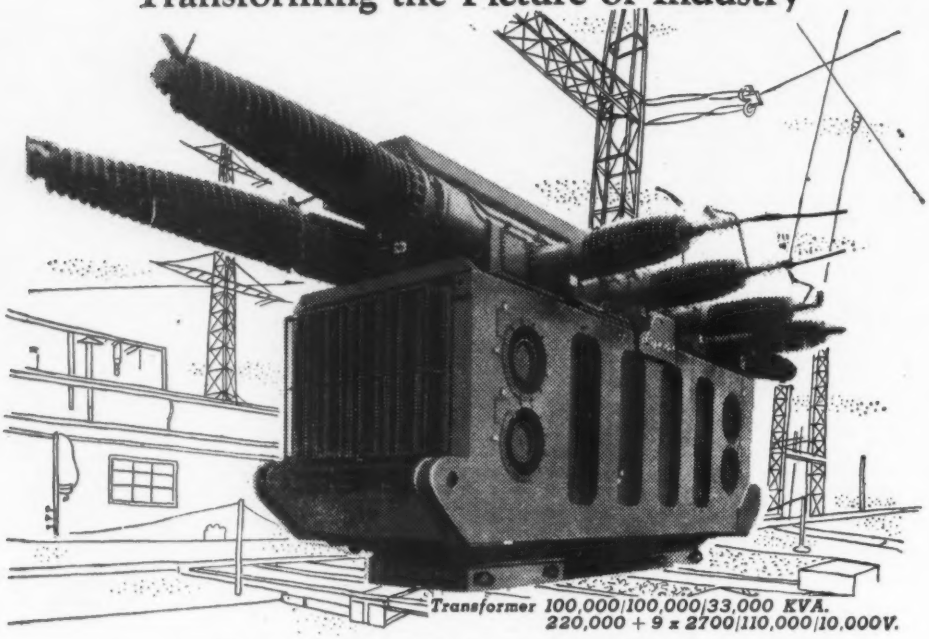

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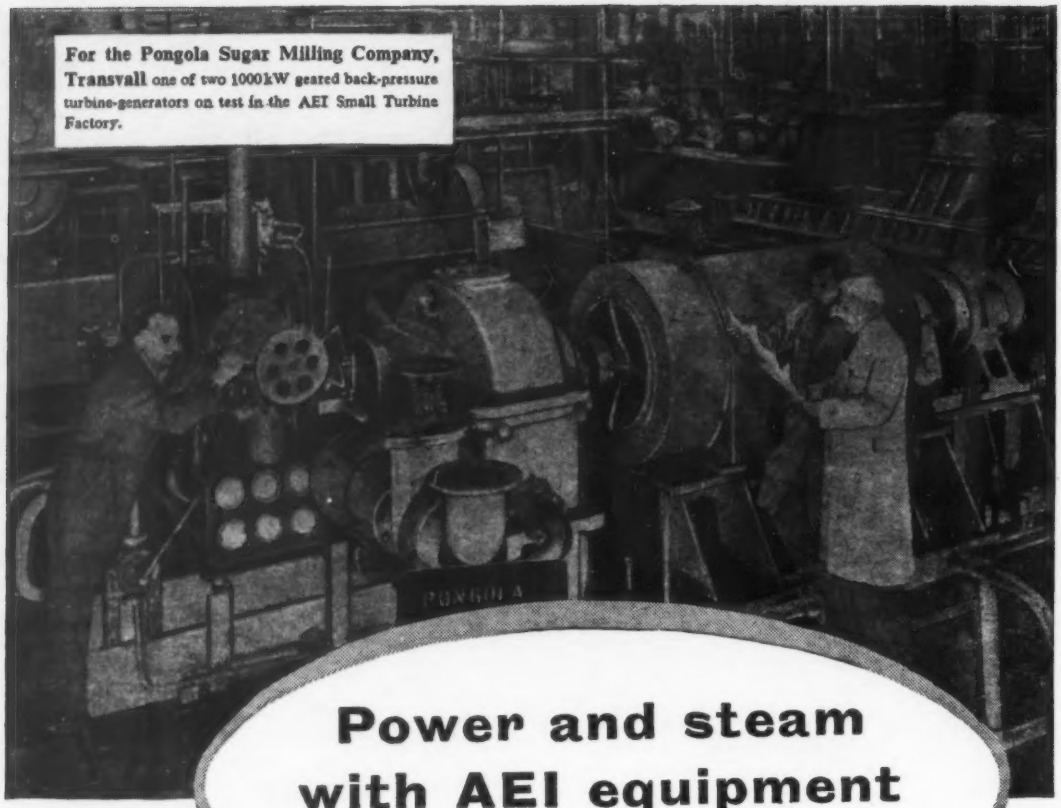

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Director
Central Water and Power Commission

Inter-connection between Hirakud Hydro-Electric System and Rourkela Thermal Power Station

THE original lay-out for the transmission system under the Hirakud Project provides for a 132 kV substation for supply of power in bulk to the Hindustan Steel Factory at Rourkela. The Steel Plant has also provided for a 75 MW Thermal Power Station to meet a part of their power requirement and also to provide for the essential element of security of power supply. Recently, an agreement has been concluded between the Government of Orissa and the Hindustan Steel Plant and it is noteworthy that its scope has far exceeded the original intentions in that it provides for the integrated operation of the generating plant in the two systems to maximum overall advantage. Although the scope of this inter-connection and the integrated operation is not, in any sense, the same as a zonal grid system, it has certain features which would be met with in the case of inter-state grids. Although system interconnections in a small way have been in existence in the past (as in the case of Madras, D.V.C., etc.,), these have been mostly confined to the administrative control of a single authority. In the case of interconnection between Madras and Kerala, the scope has been limited to the supply of an agreed block of power from one to the other. In other words, there is no provision for the integrated working of the available facilities in the two systems. In this context, the interconnection between Hirakud and Rourkela is somewhat wider in its scope as it represents two different agencies of which one has hydro generation and the other has thermal generation and the objective is to get the maximum advantage out of both. Accordingly, this paper is being presented in the hope that the experience that would be gained from the integrated operation of Hirakud and Rourkela would be of some value for working out the details of future inter-connections particularly those which would mark the beginning of regional and inter-state grids.

System Generation Capacities

The Hirakud Power system comprises two power stations: the first one located at the main Hirakud Dam, has 4 units each of 31 MW and 2 units each of 17 MW making a total installed capacity of 158 MW; the second power station utilizes the tail waters of the first and is some distance away at Chiplima containing 3 units each of 24 MW making a total installed capacity of 72 MW. The combined capacity of the two power stations amounts to 230 M.W. and based on the availability of water after providing for irrigation and flood control requirements, the continuous power (100% load factor) has been estimated at 127 MW.

The Thermal Power Station at Rourkela contains three steam turbo-alternator sets each of 25 MW and provision exists for the future addition of 2 more units of the same size. The total power demand of the Steel Plant, including the fertilizer plant, has been estimated at 110 MW. The original intention was that the Steel Plant should generate a firm output of 50 MW from this power station and purchase the balance of power requirements from the Hirakud System.

Basis for Integrated Operation

The Hirakud system is catering to a number of large industrial establishments in the Orissa State, some of which, notably the aluminium industry, work at very high load factors. Assuming that the overall system load factor is 70%, the total energy available from the hydroelectric stations would correspond to 181 MW at 70% L.F. (which is equivallent to 127 MW

at 100% given earlier). As against this, the installed capacity is 230 MW and the firm capacity, after excluding one large unit of 31 MW, would be 199 MW.

In the case of Rourkela Power Station, one 25 MW unit out of the three, would normally be a standby and the other two units would be on continuous service. This places the firm capacity of the station at 50 MW and the energy output would more or less correspond to the load factor of the Steel Plant. It was thus apparent that there are certain highly complementary factors in the working of the two power stations and that an integrated operation would contribute to overall advantage. The Hirakud System with its limitations of water availability could easily absorb a substantial amount of energy from a thermal plant and thereby increase the firm salable power by making better use of the available installed capacity. The Rourkela Steel Plant have at their disposal substantial quantities of surplus fuel in the form of coke breeze and industrial gases, which could be utilized for power generation to such an extent that all the three machines could be put into continuous service on full load except during overhauls. In fact, by arranging the annual maintenance programme of the thermal plant in such a way that it coincides with the high water conditions at the Hirakud Reservoir, it should be possible to obtain from the Thermal Power Station a high availability factor of 90% and more. The following figures illustrate the power availability position if the two stations are operated separately and alternatively in an integrated manner:—

	Installed capacity	*Firm capacity (excluding one large machine)*	*Energy content expressed in MW (at 70% LF)*
	MW	MW	
I Hirakud	230	199	181
Rourkela	75	50	50
Aggregate for Hirakud and Rourkela Power stations working separately	305	249	231
II Hirakud	230	199	181
Rourkela	75	75 $\frac{75\times0.9^*}{0.7^{**}}$	96
Aggregate for Hirakud and Rourkela working in an integrated manner	305	274	277

Note: *Availability factor of Thermal Plant : 90
**System load factor : 70

If may be noted from the above that when operated in an integrated manner, the two systems would be able to cater for a firm system peak load of 274 MW and an energy supply equivalent to 277 MW at 70% load factor. This represents a gain of about 10% in the former and about 20% in the latter. Thus, it was obvious that a suitable method of integrated working should be devised which would be equitable to both the parties and would also result in maximum advantage to both the power systems. To this end, the representatives of the two parties and the Central Water and Power Commission went into the whole matter and evolved an agreed arrangement.

Features of Integrated Operation

Depending on the load requirements of the region it is intended that the two stations should be operated in a complementary manner so that the storage at the Hirakud reservoir could be put to maximum advantage. At the same time, all the three machines would be run at Rourkela continuously during low water period thereby utilizing the surplus fuels to the full extent. In order to ensure that these objectives would be realized in practice, an Operating Committee would be set up with three members, one representing the Hindustan Steel and the other the Orissa Government and the third the C.W. & P.C. This Committee is intended to fix up periodically the operating programme for power generation at the two stations and also to determine the maintenance schedules and such other factors which would lead to the smooth and economic working of the stations.

While the Hirakud System would in the balance remain the supplier of power to the Hindustan Steel Plant whose demand would eventually exceed the firm capacity available at their own power station, the broad aim was to generate the maximum possible thermal energy and send the supplies into the Hirakud Orissa network, so that the net energy would be small either way. A suitable tariff has been evolved which would allow of the surplus thermal energy being utilized by the Hirakud System on a month to month basis. Furthermore, during the first two years or so. the Hindustan Steel Plant may be able to spare a certain amount of firm power for the Hirakud system. The supply from Hirakud is given to the Steel Plant at Rourkela at 33 kV and necessary metering system to provide for the flow of power in eitheir direction has been installed.

At the present time (August 1960), only a part of the Steel Plant load has materialized and some firm power is available for the Hirakud System and it is understood that it is being gradually taken up by the latter to meet their increasing load demand. In the course of the next two years, certain valuable experience would be gained in respect of technical as well as the administrative aspects of integrated operation.

Dr. A. E. Morgan
First Chairman
TVA Board

The Tennessee Valley Authority

DURING World War I, Wilson Dam and power plant were built on the Tennessee River to produce nitrates for munitions. For 15 years thereafter a contest between proponents and opponents of public power held that installation largely inactive

In May, 1933, upon recommendation of President Franklin D. Roosevelt, the Tennessee Valley Authority was created by act of Congress. The Authority is governed by a Board of three directors, appointed by the President. In the President's words, it was to be "a corporation clothed with the power of government, but possessed with the flexibility and initiative of a private enterprise." Its aim was the unified development of the Tennessee River system by a single program for all useful purposes, especially national defense, flood control, navigation, power development, fertilizer development, improvement of agriculture, and forestry. In operation other values developed, including elimination of malaria, development of recreation facilities and improvement of fisheries.

The Tennessee, the largest branch of the Ohio, drains 40,000 square miles, mostly in Tennessee, but partly in Kentucky, Virginia, North Carolina, Georgia, Alabama and Mississippi. The French Broad and Holston rivers unite above Knoxville to form the Tennessee, which flows south-west and west through Tennessee, north Alabama, and north-east Mississippi, and then north across Tennessee and Kentucky to the Ohio. It has a total fall of 515 feet in its length of 580 miles.

Annual precipitation in the area, averaging 51 inches, is one of the heaviest in the U.S., varying in different years from 38 to 63 inches. The total annual runoff has varied from 11 to 33 inches. The extreme low flow of the river has been 4,500 cubic feet per second, and the maximum about 500,000 cubic feet per second. Control by reservoirs has greatly lessened these extremes.

The T.V.A. was created during the great depression, when increase of employment was a major issue. Beginning in June, 1933, with no organization whatsoever, in 4 months two great dams were under construction, which were finished in less than three years, turning waste man hours into enduring structures which will continue to produce wealth through the centuries.

Greatly improved standards of human relations in the construction industry were given application by adoption of the labour relations policy recently developed and applied on the Miami flood control project in Ohio. Also following that Ohio precedent and using a core engineering staff trained there, the T.V.A. carried out its major works without letting contracts, but with its own engineering and construction staff. This enabled construction to begin quickly during the depression, and created an able staff which has built 20 dams and some of the largest steam power plants in the world. The peak of T.V.A. employment, in 1942, was about 30,000 persons.

The 30 dams which the T.V.A. has built or owns or controls have a storage capacity of about 12,000,000 acre feet. The Tennessee river is now a chain of lakes. Water regulation is centred in the Chief Engineer's office. With a widespread system of recording and forecasting, the total water supply is manipulated in the interest of flood control, navigation, power development, malaria control, recreation and fisheries. The values from this complex operation are far greater than could be realized by any possible unco-ordinated undertakings.

Navigation

With 9-foot navigation for the 627 miles from the Ohio River to above Knoxville, and with locks being brought to the present standard of 600 feet long and 110 feet wide, the river traffic in 1959 was 65 times as great as in 1933, or 2,130,000,000 ton miles. Durthat year 75,000 vessels passed through the locks. Estimated annual savings in transportation costs are $25,000,000, which, after paying costs of operation, leaves a profit of about 10% on the $190,000,000 charged to navigation.

Flood Control

Flood control and navigation have first claim on T.V.A. reservoir capacity. With no great general floods during summer, it is possible in some degree to use the same storage capacity, partly for flood con-

trol and partly for power. According to T.V.A. estimates, the system has prevented $35,000,000 flood damage at Chattanooga, and can lower flood stages 2 to 4 feet at the mouth of the Ohio. A similar increase of Mississippi River flood protection by raising levees probably would cost much more than the $183,000,000 charged to T.V.A. flood control.

Electric Power

With the energetic initiative of David E. Lilienthal, one of the original directors, there was developed a programme for marketing the large amounts of power generated at T.V.A. dams. Especially with the great power demands of the atomic energy programme, steam plants have been added, two of them the largest in the United States, until today T.V.A. is the largest power producer and the largest purchaser of coal in the United States, with 3 times as much steam as waterpower capacity. It is now the sole source of power over 80,000 square miles, about twice the area of Ohio, with a population of about 5,000,000 people. It sells power at wholesale to 99 municipalities, to 51 rural electrical co-operatives, and to 30 large industries, while more than half of its total sales are to the U.S. Government, largely for the atomic energy programme.

T.V.A. prescribes conditions and maximum rates at which municipalities shall sell its power. According to official reports, during 1959 the average annual residential use in the T.V.A. area was 7,863 kilowatt hours, at a cost of 1.03c per kwh, whereas the average residential use by the United States as a whole was 3,450 kwh, at a cost of 2.52c per kwh.

This difference results in part from the inherent economy in the construction of an integrated river control system for all purposes, which makes construction less expensive than where a single purpose must bear the entire expense. Also the unified operation of 30 dams and reservoirs in a single system makes possible an economy and effectiveness in the use of water quite beyond that of a single plant.

Lower cost and resulting larger use have been somewhat favoured by the fact that, whereas private utilities would be required to pay about 52% of net earnings (about 9% of the operating cost) for income-tax, the T.V.A. and its distributing municipalities pay no income-tax. According to the T.V.A. Annual Report for 1959, American private utilities pay state and local taxes amounting to 8.6% of the total operating cost, while the T.V.A. and its distributing municipalities pay 6.8%, a difference of 1.8% of the operating cost. While private utilities pay 2.5% or more interest on their investment, T.V.A. estimates interest at 2%, a difference of perhaps 2.5% of the operating cost.

The T.V.A. electric service has been of a high order, and has markedly advanced the economy of the region. Active promotion by T.V.A. and associated public agencies, together with lower unit costs, has greatly expanded the use of electric power. In 1959 about 1,200,000 homes were served with T.V.A. power, of which about 250,000 are heated entirely by electricity, which increases the use in the home by nearly 5 times.

In 1959 the total investment in T.V.A. power was about $1,700,000,000. Large additional installations are underway. According to T.V.A. reports, its power business pays all costs and makes a profit of about 4% on the net investment for power, which is used to increase plant or to repay the cost. The 1959 Congress authorized the Authority to sell bonds, not more than $750,000,000 to be outstanding at any one time, to finance further growth.

Fertilizer

The T.V.A. statute provided for the production and sale of cheap nitrogen fertilizer. Dr. H. A. Morgan, one of the Directors, believed the great need of southern soils was phosphates, and that exclusive use of nitrates robbed the soil of essential plant nutrients. He therefore promoted phosphate fertilizers and their experimental distribution. This accelerated use of phosphates, substantially advanced southern agriculture, turning it from cotton and corn to grass and livestock, reducing soil erosion.

Forestry

Half of the T.V.A. area is forest. Beginning with the first years of the T.V.A., with co-operation of national and state forestry services, studies were made of forest conditions and possibilities, and steps were taken to increase forest productivity. This coincided with a general movement to the same effect over the country, and with technological developments for using hardwoods for papermaking. T.V.A. area forests are steadily increasing in productiveness.

Malarial Control

Before the T.V.A., endemic malaria was a chief handicap of lowland areas. In some locations more than a quarter of the population was infected. Since malaria is carried by mosquitos which breed in standing water, the process of turning the Tennessee into a series of lakes threatened to make the region uninhabitable. An early action of the T.V.A. Board was to appoint Dr. Eugene L. Bishop to deal with this problem. He did a masterful job, and the disease was eliminated from the region. It is stated that during 10 years no cases have been reported except a few brought in from outside.

Recreation

With malaria eliminated, T.V.A. lakes are a major recreation area. Seventy-five state and local parks along their shores have public facilities, and there are

(Continued on page 10)

Dr. Ajit Mozoomdar

The Outlook for Nuclear Power

Dr. Mozoomdar here surveys the recent changes in the outlook for nuclear power. This is done in five parts, of which two are published in this issue to be followed later by the subsequent parts.—Editor.

I. The Development of New Technology: Alternative Reactor Types

THE cut-back in the British nuclear power programme, announced in the White Paper, of June 1960, has been widely discussed. At the time of the First Geneva Conference on the Peaceful Uses of Atomic Energy, in 1955, it had seemed that within a decade nuclear energy would be established in many countries as a source of electrical power comparable in importance to the conventional sources—coal, oil and water-power. Till 1958 there were expectations that under Western European conditions the cost of power from nuclear sources would be equal to the cost of conventional power by 1961 or 1962, and that thereafter nuclear power would rapidly become cheaper than its rivals. Today the most optimistic estimate places the break-even point at 1966, and does not visualise any definite cost advantage for nuclear power till 1970 or so.

The shift in relative advantages, however, has not been due to lack of progress in nuclear technology, whose advance has more than fulfilled early expectations. Important developments were reported to the Second Geneva Conference in 1958, and there have been further advances since then. In the last five years valuable experience has been gained in the construction of large-sized nuclear power stations of at least three different types; better utilisation of the thermal energy in nuclear fuel is being achieved; alternative fuel cycles have been studied; and the international price of the primary nuclear fuel—natural uranium—has been cut by almost half.

The balance has been tilted against nuclear power, in Western Europe especially, by two factors—the huge increase in available supplies of oil and natural gas, and a considerable rise in the efficiency of conventional thermal power stations of large capacity. Another incidental factor, the rise in interest rates, has also worked against the economy of nuclear power which involves comparatively larger capital investment but much smaller fuel costs. These conditions are not necessarily reproduced in other regions: each country has a different balance of availability and distribution of fossil fuels, water-power resources and nuclear fuels. For instance, Japan has to rely on imported fuel for a quarter of its energy needs, and hopes to reduce its foreign exchange liability on this account by developing nuclear power. Sweden expects to harness its hydro-electric resources fully in the next decade, and has next to turn either to peat and oil shale or to uranium, all of which occur extensively in the country.

Abundance of coal and oil, however, likely to be available at stable prices, and high capital charges, have long been features of the U.S. fuel economy. The American approach to nuclear power, therefore, has from the first been marked by caution. Their programme lays emphasis on experimentation with a wide variety of reactor types, aiming at developing techniques which, it is hoped, will in the long run produce nuclear power cheaper than conventional power in the U.S., which is cheap enough compared to most other countries. In Britain, on the other hand, the decision was taken in the early fifties to attempt a quick break-through on a narrow front. The plan was to build a number of commercial power stations based on an established type of reactor—using natural uranium as fuel, encased in a magnesium alloy, with graphite as moderator, the system cooled by carbon dioxide gas—so as to gain extensive operating experience, concentrating on developing the technology of this reactor to obtain increasing efficiencies of fuel-utilisation and heat-transfer. At the same time work was also started on a reactor of the fast breeder type, being the most advanced system then considered feasible. With much smaller financial resources and engineering capacity than the Americans, this seemed to offer the best chance of gaining a lead in the new technological revolution, and especially in the race to develop a new export industry. While the slowing down of the nuclear station construction programme in the U.K. itself must be considered a setback in this race, the issue is still far from being decided.

This refers, however, to large nuclear stations, of

150 MW and above, suitable for base loads. Although power from nuclear stations up to, say, 50 MW capacity, is not yet within sight of being competitive with power from coal or oil fired stations of the same size, the U.S. appears to have a considerable lead in the development of reactors suitable for small and medium-size stations. This is because enriched nuclear fuel, essential for small power reactors, is available in quantity from American isotope separation plants built for military purposes, and operating experience of these types of reactors is accumulating rapidly from those built for submarine propulsion and for use in remote military installations. The U.S has an ambitious programme of small reactor demonstrations for civilian use. In the construction of prototype small-size reactors the U.S.S.R. is also ahead of Britain, where designs for reactors suitable for marine propulsion are still in the experimental stage. It appears from the recent Symposium on small and medium power reactors arranged by the International Atomic Energy Agency that the cost picture for these reactors is brighter than it was in 1958.

* * * *

It has been observed that there is no precedent in industrial history for investment in a comparatively untried technology on the scale that is going into the development of nuclear power. That this development effort is necessary is not seriously disputed, since at some future date almost all countries will come to depend increasingly on new sources of energy to replace wasting resources of coal and oil and saturated hydro-electric potential. The questions that arise are the extent to which each country needs to make a separate effort to develop the new technology, the directions in which this effort may be most profitably applied, and the speed with which power reactors working on a commercial scale should be set up.

The difficulty is that such a variety of reactor types lies within the range of possibility. Considering the three possible nuclear fuels (two isotopes of uranium and plutonium) two other elements which can be converted into fuel in reactors (thorium and the third isotope of uranium), only four of the possible moderators (graphite, water, heavy water and beryllium) and five possible types of coolants (gas, water, heavy water, liquid metals and organic fluids), and further taking into account different structures of the reactor core, about nine hundred different combinations are theoretically possible. And out of these at least a hundred are not obviously unfeasible. Again, of the systems which appear to be feasible, some would only become practicable after extensive materials testing and development of appppropriate techniques. Moreover at this stage it seems to be very unlikely that any one reactor system will emerge as the "best" system under all conditions.

The types of power reactors which are being developed at the present time may be divided into the following categories—

Reactors fuelled with natural uranium.
Reactors fuelled with enriched uranium.
Converter and breeder reactors (which produce more fissile material).

Reactors of the first two classes only, on a commercial scale, are either in operation or under construction, while the conversion into fissile material of thorium and of the non-fissionable isotope occurring in natural uranium is being intensively studied in experimental reactors of the third category. Natural uranium reactors in operation are those in U.K. and France (graphite-moderated and gas cooled), U.S.S.R. (graphite-moderated and water-cooled), and Canada (moderated and cooled with heavy water). The U.S. programme has concentrated in its earlier stages on enriched uranium reactors moderated and cooled with water, and similar reactors have also been independently designed in the U.S.S.R. All these are collectively referred to as the first-generation nuclear stations. The second-generation stations, likely to be available from 1965 or so, would represent mainly engineering developments of these basic types, but may also include the graphite moderated and sodium-cooled, and organic-moderated and cooled reactors. These stations should enable much more energy to be extracted from nuclear fuels (higher "burn-up"), besides incorporating better heat-transfer techniques. Third generation stations of breeder reactors are not expected to be practicable before 1970.

Since only at that stage will be extraction of usable energy from nuclear fuel be sufficiently large to ensure a rapid decline in the cost of generating nuclear power, it might have been safer, for those countries that are adequately endowed with conventional sources of power, to avoid large investments in nuclear power generation in the sixties. But there was another factor to be considered. The advanced reactors to be set up later will require highly enriched fuel, and there are only two ways of obtaining it. The first is by separating the isotopes of uranium by gaseous diffusion, which requires considerable investment in plant and also large amounts of cheap electricity. The establishment of new isotope-separation plants would hardly be economical if the cost could not be passed on partly to the military budget. So that the U.S.A. is today virtually the only source from which other countries can get large quantities of uranium enriched with a high percentage of its fissile isotopes. But natural uranium can also be enriched by the use of plutonium, which is produced by irradiating natural uranium and can thus be obtained as a bye-product in power reactors fuelled with natural uranium. By setting up a sufficient number of first-generating stations of this type, therefore, any country with uranium resources can be self-sufficient in the enriched fuel required for the operation of reactors of more advanced

types, and in particular for use in the breeder stations, when nuclear power will have reached its maturity. So the planners have been faced with a further choice of policy.

* * * *

Those opposed to large-scale investment in nuclear-power generation have sometimes also referred to the possible threat of fission-techniques being rendered obsolete by the development of commercial power from nuclear fusion—"unlimited power from sea water". The contingency seems to be remote, Since Harwell's Zeta and similar devices attempted in the U.S.A. and U.S.S.R. for achieving controlled nuclear fusion have so far been unsuccessful, and it will be a long step from success in the laboratory to the development of a technology for operating at 5000°C and above. The other possible revolution in nuclear technology—direct conversion of fission energy into electrical power, without converting into heat and passing through boilers and turbines—is also a very distant dream.

II. The UK Nuclear Power Programme: Trend of Costs

No country has staked so much on the development of nuclear power as Britain. In selecting a single type of reactor for intensive development, and concentrating longer range research on a very small number of other types, the U.K. Atomic Energy Authority has taken a calculated risk. As early as 1953 it decided to proceed with the construction of a full-scale power station at Calder Hall, in Cumberland, using natural uranium as fuel, graphite-moderated and gas-cooled.

The first White Paper on nuclear power development, in 1955, provided for nuclear capacity of 1500-2000 MW to be set up by 1965 for commercial use. The ten year programme was considerably stepped up in 1957, to provide for installed capacity of 5000-6000 MW by 1966. The 1957 programme has now been curtailed. But with the new targets of 3000 MW nuclear power by 1966, 5000 MW by 1968 and 6000 MW by 1970, the programme is still bigger than the 1955 programme, and it remains the most ambitious programme in any country for the construction of full-scale nuclear power stations.

The Calder Hall reactors, each of 70 MW, became critical in 1956 and 1958; part of the similar station at Chapelcross, in Dumfriesshire, Scotland, was commissioned last year. The construction of four stations of the Central Electricity Generating Board is going on, to be completed before 1962; at Berkeley, on the Severn in Gloucestershire (capacity 275 MW expected to be critical in early 1961), at Bradwell in Essex (300 MW); at Hunterston, near Glasgow (320 MW); and the largest at Hinkley Point in Somerset (500 MW). Also under construction and to be completed by 1964, is the 500 MW station at Trawsfynydd in North Wales (to be operated in conjunction with a major pumped water-storage power project). Orders have recently been placed for the 550 MW plant at Dungeness, in Kent, and the 650 MW plant at Sizewell in Suffolk is expected to be ordered very soon. Under the revised nuclear programme of June 1960, work on four other projected stations, one of which was to have been in Northern Ireland and another on the Isle of Wight, has been slowed down.

* * * *

The U.K.A.E.A.'s long term programme in 1955 visualised nuclear power development in three distinct stages. In the first stage, dual purpose plants producing substantial quantities of plutonium as well as 60-70 MW power from each reactor would be followed by reactors with larger core sizes, with power output of about 150 MW per reactor. The second stage of development would be marked by a change-over to reactors of higher rating, using as fuel natural uranium enriched with plutonium obtained from the first stage reactors. In the third stage breeder stations would be set up with perhaps 100 times more efficient fuel utilisation than in stage one reactors.

Subsequently the three-stage concept has been replaced by a more flexible reactor research policy. A prototype advanced gas-cooled reactor is now being put up at Windscale, with uranium oxide as fuel and beryllium or stainless steel replacing magnesium alloy for canning the fuel, which will enable operations at 600°c instead of 400°c as in the commercial stations under construction. Achievement of even higher temperatures is the purpose of the experimental project at Winifrid Heath, for a helium-cooled enriched-uranium graphite-moderated reactor, undertaken jointly by the Authority and the European Nuclear Energy Agency. Although not a breeder, this reactor is expected to have a conversion ratio very near unity, working on the U-233/Thorium cycle", Second-stage systems such as water-moderated and sodium-graphite systems appear to have receded to the background. Meanwhile progress has been made with third-stage reactors. The 15 MW experimental fast breeder at Dounreay, in the extreme north of Scotland, was completed in 1959, a little later than Russia's 5 MW fast breeder but well before the American fast breeder near Detroit, still under construction. A fast breeder uses Uranium 235 or plutonium as fuel in the core, without a moderator, and uranium 238 or thorium in a blanket around the core; neutrons emitted by fission of the core convert the material in the blanket, which is not normally fissile, into fissile material. There is a breeding gain if more fissile material is produced in the blanket than is burned in

the core. It is hoped to design a prototype fast-breeder station in the 1970's. Although earlier reports had indicated that high priority would also be given to the development of thermal (i.e. moderated) breeder reactors working on the U-233/thorium cycle, work so far appears to have been confined to zero-energy reactors. The U.K. A.E.A.'s policy of concentrating on the development of only two types of reactors has of late come under increasing fire from the nuclear engineering industry.

* * * *

While anxiety to take the lead in the development of the new technology has been the motive force behind Britain's massive nuclear effort, large-scale investment on nuclear power stations would hardly have been undertaken if a difficulty in meeting the country's future power requirements from fossil fuels had not been foreseen, and if it had not appeared that quite early in the programme nuclear power would be available more or less at the same cost as conventional power. The 1955 White Paper anticipated a 350% increase in the demand for electricity by 1975, and calculated that the coal and oil required for power generation alone might rise to 100 million tons of coal-equivalent a year. Mining costs were rising, labour for mines scarce; and considerable investment would be needed merely to maintain Britain's coal output at the existing level. Refinery capacity for imported crude oil, which expanded from 5 million tons in 1948 to 29 million tons in 1956, could be expected to go up further, but it was probable that the increased supplies would be available at higher costs. The expanded nuclear programme of 1957 was, therefore, designed to save about 18 million tons of coal-equivalent by 1965. The feeling was that for Britain nuclear power had been harnessed just in time.

But now the position seems to have changed radically. The O.E.E.C. Survey of Europe's energy requirements, published early 1960, highlighted the oil surplus available from Caribbean and European refineries and the slump in freight rates adequate oil supplies in the next decade will not merely be available at existing prices but possibly even at lower prices. After mechanisation in British coal mines, and with surplus American coal on offer, there will not only be no difficulty in obtaining the additional coal requirements in 1965, but the Coal Board has had to reassure miners against redundancy. Mining costs also will not rise as much as anticipated earlier. So further investment in nuclear power in Britain will depend increasingly on the prospects of an early reduction in its generation costs.

* * * *

The capital cost of nuclear power plants is considerably higher than that of coal and oil-fired plants, because of the complexity and size of the nuclear furnace, the special materials used, high safety factors employed in the design and the cost of shielding and instrumentation. For Calder Hall the capital cost came to £ 145 per KW installed, for Berkeley and Bradwell about £ 160; expectations that for the later stations the cost may go down to £100 may not be fulfilled. It is possible, however, that with the smaller core size, the advanced gas-cooled reactor of the seventies may cost about £75 a KW, while the cost of the latest coal-fired stations of comparable size would be about £40. So far as works costs are concerned, there is no reason to think that the maintenance and operating cost of nuclear stations will be significantly different from those of conventional stations. It is not easy, however, to compare fuel costs, because the life of the initial nuclear charge and the frequency of replacements cannot be predicted with certainty, and the cost of reprocessing once-used fuel is also uncertain; besides alternative methods of recycling fuel have to be considered, and the extent of credit which should be allowed for the plutonium recovered from the used fuel is doubtful. Comparisons between the estimated cost per unit of nuclear power and the cost of conventional power will also vary according to the rate of interest assumed on the fuel inventory, the rate of amortisation and the load factor at which the station is assumed to operate. In the U.K. it has been customary to assume 8% capital charges, 5% interest on fuel and operation at 75% load factor.

In 1955 it has been estimated that by 1960 the cost of nuclear power in the U.K. would lie between 0.43d and 0.59 d per unit. By 1958 these estimates had to be revised. The thermal efficiency of the new stations was higher than at Calder Hall, but this gain would be more than offset by higher site-development costs than anticipated earlier, a lower imputed value for recovered plutonium, a 10% rise in the general price level, and a rise in the interest rate from 4 to 5%. The new estimate put the cost per unit between 0.59 d and 0.66 d for the stations to be commissioned in 1962. On the other hand, the costs of conventional power in the U.K., which had been expected to rise from 0.60 d in 1960 to 0.67 d in 1970, was now expected to fall from about 0.66 d in 1960 to 0.47 d in 1970.

It has been stated in Parliament recently that nuclear power in the U.K. is expected to be available at the same cost as conventional power in 1965 or so, and a few months ago, in the World Power Conference at Madrid, Sir Christopher Hinton ventured a little further into prophecy. He thought that in 1964 the cost per unit of power from new coal-fired stations in the U.K. would be 0.55 d, whereas nuclear power would cost 0.60 d; by 1966, the two costs would be equal between 0.50 d and 0.55 d. At that time the U.K. would benefit from lower uranium prices also. Looking even further ahead he predicted that whereas conventional power costs would level off at 0.5 d in

(Continued on page 10)

The Kariba Dam is being built on the Zambesi River to provide hydro-electric power for Central Africa.

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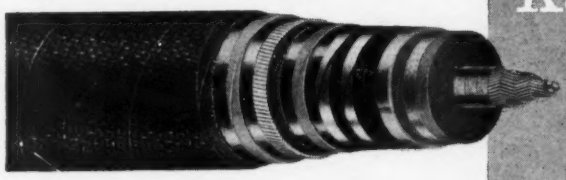

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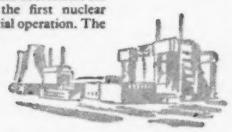

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Pollution Control in Industries

THE Planning Commission has laid considerable importance on the immediate need for setting up of heavy industries throughout the country. For rapid industrialisation, the production of steel is also one of primary importance. In the development plans of the country, considerable emphasis has, therefore, been laid and rightly so in setting up steel plants and speeding up the progress of manufacture of steel. One important aspect in this connection which deserves closer attention is that of prevention of pollution of water and air around the industries, which are now being set up, all over the country. Unless steps are taken right from the beginning to keep a proper check on the aspect of pollution prevention, the problem would be far more serious at a later stage when it would be necessary to spend more in safeguarding the public health of the areas where such industries and mills are being set up.

It is essential that some sort of legislation is introduced—either in the Parliament as a Central Act or in the various States—so that the treatment of industrial wastes is controlled by the public health authorities of the concerned States in which such industries are located. The industries themselves are naturally keen to have the supply of water and power for the successful running of their installations but sufficient thought and care are not initially given in dealing with the disposal of the industrial wastes and thereby pollution of water and air all round the area. It is not always appreciated that the industries, in order to maintain happy public relations, should ensure to keep the atmosphere clean and the sources of water supply free from any objectionable matters.

It is not always practicable to prevent the industrial wastes to run into a near-by flowing stream but it is certainly possible to treat such wastes so as to remove the pollution and convert the same to an acceptable standard. With the advancement of public health engineering and science, several methods of treatment of industrial wastes and pollution control have evolved. It is only necessary that the authorities in charge of the industrial installations are made conscious of the dangers that may follow due to non-introduction of scientific treatment and control of pollution of air and water. Modern techniques have been evolved in lowering down the costs of treatment and increasing the effectiveness of pollution control.

To ensure rigid adherence of the prohibition laws, it is desirable that the responsiblity for control of pollution is vested on the authority controlling the individual industry. It should be made widely known to the industrial undertakings that failure to carry out an effective control may mean stoppage of the running of the plants until such effective measures are introduced. It will not be out of place to mention that in the area of operation of the Damodar Valley where the general and all round development of the valley has been entrusted to the Damodar Valley Corporation, the responsibility of pollution control has also been vested on the Damodar Valley Corporation under the Damodar Valley Corporation Act.

The authority in charge of industrial undertakings should not only examine the existing control measures, but they should suggest installation of treatment plants to ensure adequate methods of wastes and pollution control. It is, however, true that prevention of pollution is not only a complex problem but it adds to the cost of produce coming out of these industries. This cost should not, however, be grudged by the people in general to ensure preservation of public health of the society.

In designing treatment plants and determining to what extent pollution control is to be effected, it is essential to have a clear knowledge about the effects of the different wastes disposals from the different industrial installations. On this knowledge, the method of disposal and means of treatment would largely depend. As the source of supply in most of the villages and outlying areas in this country is from the open streams, it is important to find out the capacity of the streams, flowing by the industrial installations, to dilute various wastes to a non-objectionable limit. In our country, complete segregation of wastes streams, which would otherwise enable treatment of reduced quantities of wastes is not possible till separate arrangements for potable water supply in each and every village of the country can be ensured by the State.

Certain common effects of industrial wastes on

sources of water supply are—

(a) addition of dissolved solids,

(b) suspended matter,

(c) increase in temperature,

(d) increase in acidity.

(e) increase in alkalinity.

(f) increase in hardness.

There is also the effect of change in the taste and odour of the water though chemically such water may be free from any pollution. These effects together with the effect of increase in temperature, seriously affect the aquatic life as there is always an upper limit of temperature for fish and aquatic plant life. The temperature also plays an important part in the oxygen content dissolved in water. Where the waste water is again reutilised as in the case of supplying cooling water to thermal stations, any increase in temperature of the main source of water supply would lower the efficiency of the installation. The variation in oxygen content will naturally have an effect on the animal or aquatic plant life. In respect of the acidity or alkalinity, a range of pH value, between 6 and 8 is always desirable.

In this country, we have unfortunately very meagre data in connection with the Air Sampling. The Meteorological Department of the Government of India does not ordinarily deal with such studies and it is essential that Air Sampling and tests should be carried out simultaneously when the proposals for setting up large scale industries are initiated.

The industrial undertakings are often very reluctant to recognise the extent of air pollution lest they are forced to contribute to measures in preventing such pollution by law. Here again, the industrial management would perhaps maintain good public relations if steps are initially taken by them to prevent atmospheric pollution. The defence that the industrial management often puts forward is that since every individual contributes to air pollution, the industrial undertakings should not be separately asked to pay for any pollution control. This atmospheric pollution is particularly important in the case of large steel plants now being located all over the country. There is no doubt that this control is rather costly and adds to the cost of the steel, but careful planning from the initial stage would help in keeping down the cost of pollution control to a large extent and ultimately the result that is achieved, would pay for the cost of such control. Considerable research and studies are necessary in this direction and it is hoped that adequate steps would be taken in the appropriate quarters to ensure pollution control in the larger interest of the country.

(Continued from page 4)

THE TENNESSEE VALLEY AUTHORITY

thousands of summer cottages. "Person-day visits" in 1956 were 27,800,000. In 1959 there were 45,000 recreational craft on the lakes. Fishing on T.V.A. lakes has steadily improved. Tests indicate that less than a fifth of the fish are ever caught. (The commercial fish catch amounted to about 4,700,000 pounds in 1959.)

The overall result of the Tennessee Valley Authority has been a release of productive capacity and a complex of values not achieved by any other river development programme in the nation.

—By Courtesy of *Dictionary of American History*

(Continued from page 8)

THE OUTLOOK FOR NUCLEAR POWER

1974, nuclear power costs would continue to fall, dropping below 0.45 d in 1972. These projections are, of course, no more than informed guesses.

* * * *

The hopes with which the engineering industry in the U.K. had gone into the development of nuclear power have not been entirely fulfilled so far, and there have been amalgamations to reduce the number of firms competing for limited business. Even the revised programme provides, however, for the construction of one new station each year for the next few years. Besides the U.K. is supplying one nuclear station to Italy and another to Japan.

To be continued

(Continued from page 23)

SURVEY IN RIVER VALLEY PROJECTS

each River Valley Project so that full time and undivided attention can be devoted by the men employed in this wing.

Moreover in a highly mechanised construction project as at Maithon or Panchet Hill it is all the more necessary to institute an independent department to lessen the burden on the man in the main construction work. By having such an organisation and division of work better efficiency can be expected and greater control can be exercised on the works as the surveys and measurements are done by an independent body to countercheck where necessary. The cost analysis for work carried out by the help of data provided by such an independent body will be more accurate and give a clear picture of the works carried out. It therefore becomes crystal clear about the importance of the surveys and it is therefore hoped that the River Valley Project authorities will realise this and give a prominent place to this survey work.

Dr. L. E. Benson
Incharge, Metal Group
and
J. Johnson
Incharge, Metallurgical Section
M-V Research Department
Associated Electrical Industries Limited

Inspection and Testing of Materials for Turbines and Generators - II

[*Continued from November 1960 issue*]

Castings

SOME indication has been given before of the difficulties encountered in producing sound steel ingots. Even with the best possible ingot mould and with conditions designed to promote progressive solidification and with as nearly perfect feeding as possible, there is nearly always some axial porosity. How much more difficult, therefore, is the task of the steel-founder who has to make castings of varying section which are impossible to feed perfectly and which involve additional risks due to trapped gas, contraction cracks due to uneven cooling, and so on.

In even the simplest half-cylinder casting for a steam turbine there are marked changes in section between flanges and cylinder wall and at steam connections and passages. A valve chest with its box-like shape and internal partitions presents additional difficulties, and when the two are combined as in the casting shown in Fig. 1, the moulding and pouring procedure require very careful consideration indeed.

Apart from these difficulties turbine castings may weigh up to 15 tons after knocking out of the mould, fettling and cutting off runners and risers. With good foundry practice they may weigh about twice as much before the risers are removed, and Fig. 14 shows a simple half-cylinder casting with the risers still in position, being dressed.

Turbine castings must not only have ample heads but they must be cast under the best conditions; that is (a) to give internal soundness where this is important, and (b) to place unavoidable defects where they do not matter or where they can be revealed and remedied during subsequent manufacture.

It must be recognized that the casting with the best external appearance is not necessarily the soundest one. The casting shown in Fig. 14 was correctly cast with the heavy flange uppermost and

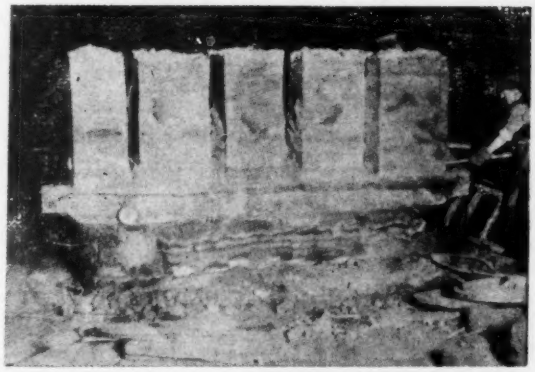


Fig. 14. A cast steel half-cylinder and risers removed from the mould.

with the risers, which act just like the feeder head of an ingot, directly on top of the flange, because this will promote progressive solidification from the bottom upwards with a downward flow of still liquid metal to accommodate the contraction that occurs on freezing. This means, however, that the flange may contain some segregation of impurities of the type occurring in the upper part of an ingot, and the sulphur print (Fig. 15) taken on the machined flange of a turbine cylinder, illustrates this. The position of

Fig. 15. A sulphur print from the flange of a cast steel turbine cylinder. The pattern of segregation indicates the arrangement of feeder heads.

the risers, or feeder heads, is clearly indicated; indeed the indications on this print are more pronounced than usual. Defects of this type in the flange are not generally a serious matter but, and this is an important point, a casting of this shape with a perfectly sound flange, and giving a clean sulphur print, would be under grave suspicion of containing serious segregation and shrinkage elsewhere, possibly hidden, through not having been cast by the proper technique.

Experience shows that the manufacture of turbine castings requires real co-operation between the designer and the founder, and important AEI castings are obtained only from a few foundries with whom there is excellent liaison. The inspection technique must also be really searching, and the founder must be willing to have defects revealed and to modify his moulding and casting technique accordingly.

At the same time the design engineer and the ultimate customer must recognize that perfect castings are not possible and must be willing to consider realistically the repair of defects when they occur.

AEI has fostered this policy for very many years and has hundreds of difficult turbine cylinder, steam chest and other castings giving trouble-free service under onerous conditions. Furthermore, this policy has not led to an increase in the percentage rejection of castings, but it has led to the adoption of improved foundry techniques with corresponding improvement in quality. It has also led to the disclosure of defects at an early stage, when they can be repaired, rather than on water test after finish-machining when they might cause rejection and might delay delivery of a complete machine.

The success of the policy referred to above has been dependent on a really revealing inspection technique, and it may be of interest to set out the routine procedure which was first developed at Trafford Park and which has been used for very many years.

This is as follows:—(i) The casting is moulded and cast by a method previously discussed and agreed. It is rough fettled, annealed and rough machined on the main flange faces and cylinder bores. (ii) The casting is pickled in acid, washed in hot lime water, allowed to dry and inspected for cracks, etc. (A satisfactory pickling procedure would be to use 25 per cent HCI cold with an inhibitor, and brush intermittently with wire brushes to remove loosened oxide. A clean surface would probably be obtained in 2-3 hours). (iii) The casting is finish-fettled, defects are cut out, all corner radii are ground as shown in Fig. 14 and magnetically tested for cracks. (This normally takes place at the foundry). (iv) Defects are repaired (hot welding is used in the case of alloy steels), the castings are immediately stress relieved, at a minimum temperature of 600°C (or higher depending on composition) and furnace cooled. The repairs are then cleaned up and proved. (v) After delivery to the works, radiological examination may be applied to difficult castings in which there is particular interest; for example, if the best foundry technique has not yet been fully established. There may also be a special inspection of casting not completely cleared at the foundry or where machining reveals a defective condition.

Although radiological examination is not applied to every casting, in the routine way that the pickling, grinding and magnetic testing technique is applied, proper facilities are provided in the Works for such tests. A radiological test laboratory, adjacent to the main turbine shop, houses a 400-kV x-ray set and is equipped with portable isotope sources of radiation. Fig. 16 shows a steam chest being set up for radiography of a weld preparation using a multi-Curie cobalt source.

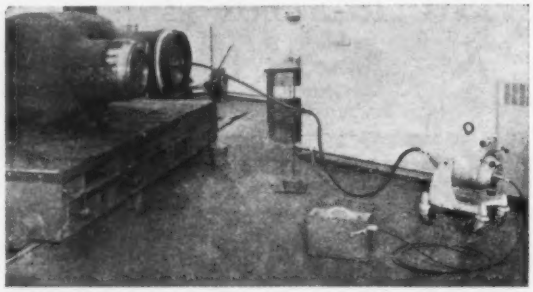


Fig. 16. Gamma radiography employing a multi-curie cobalt source. The gear for remote control is shown in the foreground.

Turbine Blades

The inspection and testing of turbine blading is dealt with on a mass production basis. All material for moving blades leaves the steelmaker's works in bar form. AEI inspectors approve each consignment before shipping and, in addition to the normal tests from each consignment, every bar of heat treated material has a hardness check.

Every bar is also stamped for identification with symbols issued by the AEI inspector, which enable the material to be traced back to the original cast of steel. In the works these symbols are transferred at different manufacturing operations to the finished product. In the case of forged blades, additional symbols relating to the heat treatment are added; thus every moving blade, whether forged or machined from bar, is identified in service with symbols which enable its history to be traced back to the original cast.

As regards inspection for defects, all machined and forged moving blades are tested for cracks magnetically as a routine, and any trouble experienced is investigated by the Research Department. As a matter of historical interest it is worth mentioning that the magnetic method of testing for cracks was developed at our Trafford Park works because of cracking troubles experienced with the early stainless steel turbine

blades and also with case-hardened and ground traction pinions.* It was first applied to turbine blades in 1923-4, and the factory was provided with equipment for routine testing of every moving blade in 1925. The method has been used continuously ever since, as has the identification scheme already mentioned.

Residual Stress Effects

Although residual stresses are perhaps not a material defect in the generally accepted sense, it is important that both forgings and castings should be substantially free from internal stresses.

In the case of turbine rotor forgings particularly, it is also important that the small stresses which are unavoidably left should be symmetrically disposed; otherwise there may be distortion on machining or in service, or possibly even premature failure by cracking. The risk of distortion in service, due to unsymmetrically disposed internal stresses, even when the stresses themselves are of a low order is, in fact, one reason for applying a routine stabilizing treatment to all turbine rotor forgings.

Very high internal stresses may be involved in oil- or even air-hardening operations, and the subsequent tempering treatment should reduce these to a low level as well as determine the mechanical properties of the steel. However, the tolerance in temperature and soaking time, between satisfactory and unsatisfactory tempering conditions, may be small, as can be seen from Fig. 17.

Fig. 18 shows the magnitude and distribution of the residual stresses left in a nickel-chromium-molybdenum oil-hardened turbine wheel of 60-ton tensile strength that had been tempered at a temperature rather below the normal range. The stresses referred to were circumferential stresses and they were estimated from the change in diameter of rings when parted from the forging.

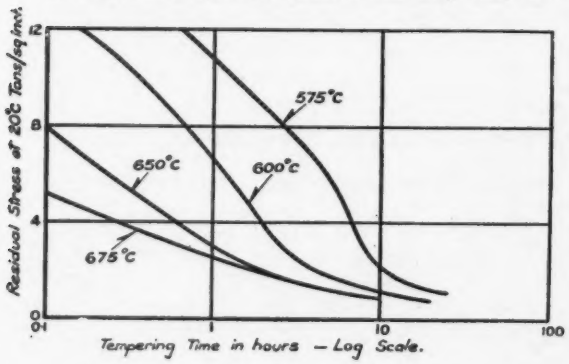


Fig. 17. The effect of tempering temperature and soaking time on residual heat treatment stresses for high tensile 3% Cr Mo steel.

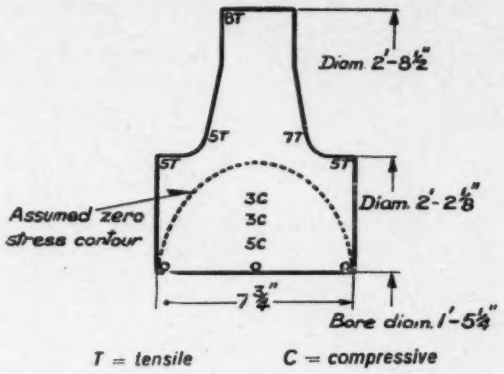


Fig. 18. Residual stresses (tons/in.²) in a hardened and tempered disc forging.

There are many other ways in which undesirable internal stresses can arise in both castings and forgings, and in welded structures also, and unfortunately there is no practical non-destructive method of testing to disclose an unsatisfactory condition of this type. It is not possible either to safeguard this risk entirely by the wording of specifications, even assuming that specification requirements are rigorously complied with by suppliers. A good deal can be done to reduce the risk, however, by an alert and informed inspection service.

Heat Exchangers

In the operation of a modern steam-driven power station, the reliability of the heat exchangers is as important as that of the turbine or generator, and considerable development in inspection and testing techniques has been necessary to keep pace with the increased unit size and increased steam temperature and pressure. This applies not only to the tubes themselves but also to the heat exchanger body and to the tube-to-tubeplate joints.

Dealing first with new tubes, it became very clear by about 1950-52 that the traditional surface inspection and over pressure tests applied to condenser and low pressure feed-water heater tubes was no longer sufficiently searching; at this time the Company sought therefore to safeguard its own position by the development and adoption of eddy current methods of tube inspection as a routine to all new tubes before assembly in the works. Fortunately this did not prove necessary, as the tube makers were all co-operative and, after a period of development, all the leading British makers of condenser and feed heater quality tubes themselves adopted eddy current methods of tube testing as a routine. This method can be made highly sensitive, and the rejection of faulty

*For a brief account of the development and early applications of the method see Non-destructive Testing by J. F. Hinsley (McDonald & Evans Limited).

tubes can be made automatic; experience now indicates that its adoption has done a great deal to ensure the supply of tubes of a consistent and very high standard of quality.

Fig. 19 shows a cross-section of a tube with a serious longitudinal defect 0.020 in. deep which might not be visible but which would be readily revealed by eddy current test.

The eddy current method employed is similar in principle to that applied to the inspection of tube bores for pitting corrosion after a period of service except that, for that purpose the search coils must, of necessity, be passed through the tube bores. For tube inspection at the maker's works the tubes can more conveniently be passed through the search coils. The frequency selected for the testing of new tubes is such that full penetration of the tube wall is achieved, so that from this point of view the energizing and search coils may be either external or internal.

For both purposes the principles of the method consist in measuring a selected component of the impedance of a short length of the tube wall under the influence of induced currents of medium frequency.

The most common method of examination provides for continuous comparison of the impedence of two adjacent portions of the tube wall. In this way, the effects of grain size, composition, hardness, wall thickness, and other variations in physical properties are largely eliminated, and the incidence of a defect in the tube material within one of the coils will produce an unbalance effect which can be immediately related to material unsoundness.

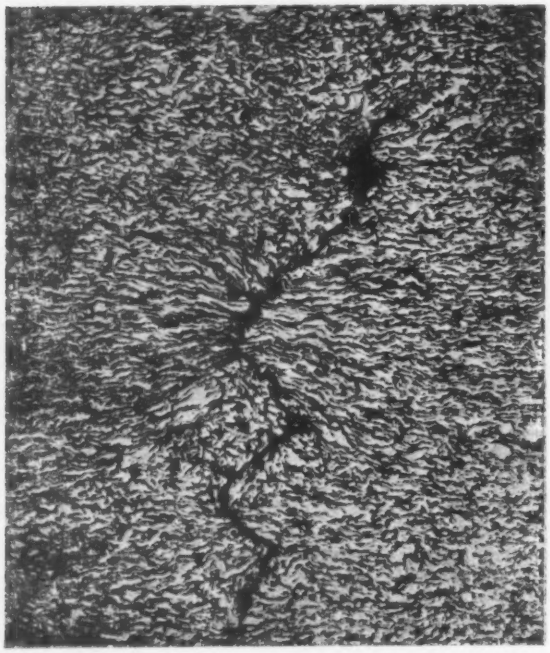


Fig. 19. Etched transverse section of a heater tube showing a defect 0.020 in. deep not visible on the tube surface.

The same methods ensure satisfactory quality in tubes for the higher pressure feed-water heaters manufactured today where the corrosion problem is reduced but where failure to tubes by leaking can have more serious consequences. A tube failure in the body of a high pressureheater may shut down the plant or seriously impair its efficiency, and almost invariably the water jet produced at the fault will quickly cause extensive damage to a large number of tubes in its vicinity. Failure of a tube within the tubeplate or even slight leakage at the tubeplate joint, due to external surface defects such as draw marks or seams may, under high pressure conditions, erode away so much of the tubeplate that repair becomes a major operation. Indeed, the degree of tube-to-tubeplate joint tightness required to ensure reliability, in service, of a high-pressure feed-water heater, has provided a testing problem apart from that of tube quality.

Low pressure feed-water heaters normally have a roller expanded joint between tube and tubeplate as shown in Fig. 20 (a). Higher pressures, however, have led to the development of tube-to-tubeplate joints incorporating a seal weld with a roller expanded joint as a supplementary safeguard and to provide support for the tube as shown in Fig. 20(b).

For testing an assembled high-pressure heater tube nest the conventional hydraulic test is not sufficiently sensitive to very small leaks. It can be much improved by maintaining the pressure for very long periods, say up to 72 hours, and by applying a uniformly sprayed coating of talc on the tubeplate surface to accentuate the appearance of any slight weepages of water. However, gas penetrant techniques are of greater sensiti-

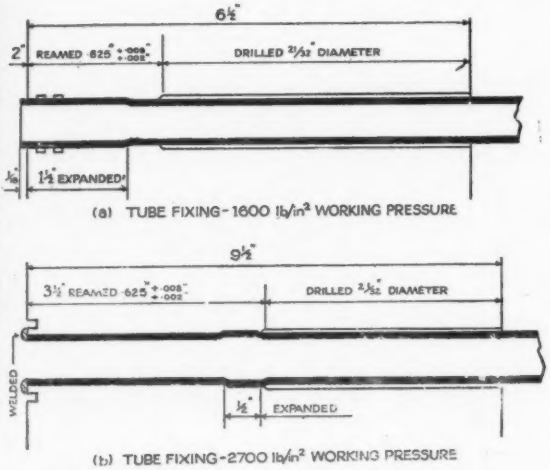


Fig. 20. Methods of fixing feed-water heater tubes into a steel tube-plate.

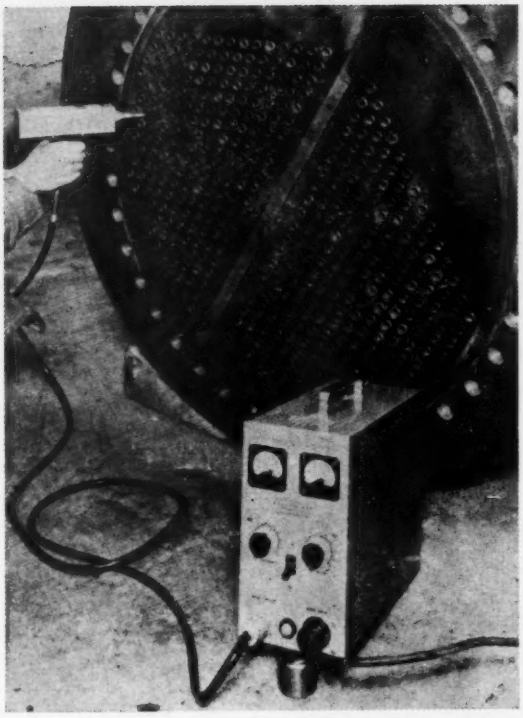


Fig. 21. A halogen leak detector testing tube-to-tube plate welds on a high pressure feed-water heater.

vity and the halogen leak detector has been adapted successfully to heater inspection (Fig. 21). The probe head carries a special adapter for use on tube-welds. An audible signal fed to ear-phones gives the operator warning of a leaky weld. Care is needed in the application of the test in the open shop, because of its indiscriminate sensitivity to any stray halogen ions, and the ease with which the test cell can be 'poisoned' in the presence of heavy concentration of halogenized vapour from large leaks.

Heater shells typify a number of similar fabricated structures of the pressure vessel type demanding a high quality of material and construction. Plate material for this purpose is obtained to specifications designed to ensure uniform properties and good weldability, but it may require further inspection for the most onerous conditions.

Among the many applications of ultrasonic inspection may be mentioned its use in testing such plate for laminations. The elimination of seriously laminated plate is an obvious necessity, but it is equally important when using steel plate for highly stressed fabricated structures, to guard against the incidence of widely dispersed laminations. Individually these may be of small size and possible have no significant effect on the strength of the plate as a whole, but they must be avoided in the vicinity of stressed welds. A technique is employed on which, for sound plate, the regular multiple echo pattern with smooth attenuation is obtained as shown in Fig. 22(a), whilst the irregularly spaced pattern with greater attenuation is obtained from a region containing dispersed laminar discontinuities as seen in Fig. 22(b). An extensive lamination at or near the mid-thickness may give a pattern similar to that shown in Fig. 22(a) but with only half the distance between successive peaks.

Radiological examination of the butt-welded joints of a heater shell is, of course applied in accordance with the best possible practice prescribed for class I pressure vessel work. Where conditions do not make radiography mandatory, it is still of considerable value, in maintaining a high standard of welding, to have radiological facilities available. Mobile equip-

Ultrasonic inspection technique for steel plate.

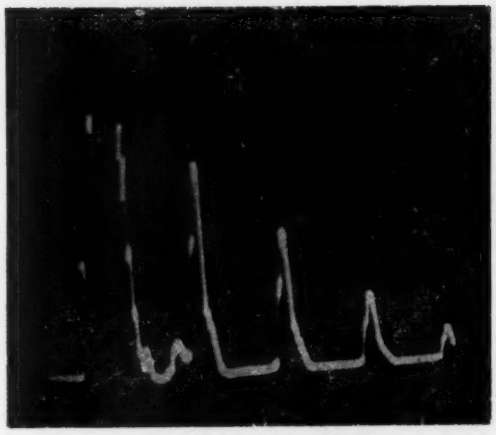
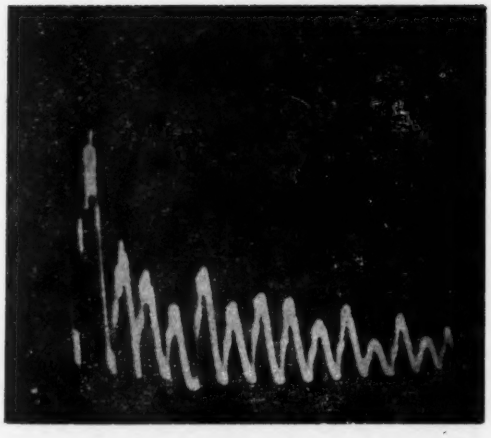


Fig. 22 (a) Trace from sound plate.



(b) Trace from laminated plate.

ment has proved its value and can be used on work in course of fabrication on the factory floor (Fig. 23).

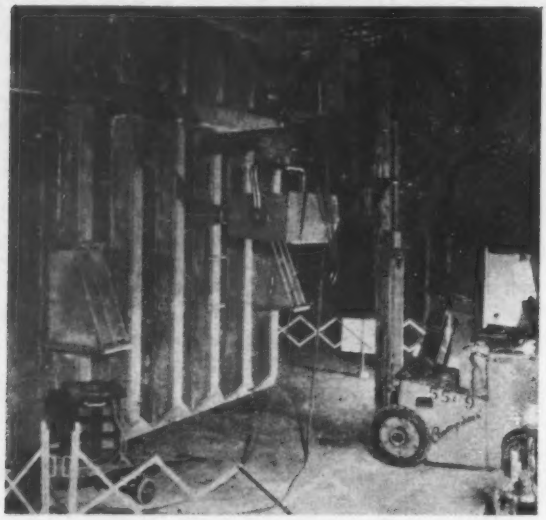


Fig. 23. A mobile 250-kV X-ray set in operation.

Tests on other Components

This article has, of necessity, been concerned with the inspection and testing of a limited number of components and materials, but the quality and uniformity of many other materials are vital to the reliability of machines in service and these are, in fact, also catered for. The variety of materials dealt with can be illustrated by the following examples:—(i) Conductor materials, including the silver bearing copper windings of generator rotors, which derive their characteristic properties from a small amount of cold work as well as from composition. (ii) Tool steel collector rings. (iii) Bolting materials including both high strength materials for normal temperatures and special alloys for high steam temperatures. (iv) White-metal lined bearings.

Although it is not possible to deal with the methods of inspection and testing applied to these and other materials, it is hoped that enough has been written to demonstrate the importance of the role that an efficient inspection service can play in ensuring the quality of the materials used in turbines and generators and hence the reliability in service of the machines themselves.

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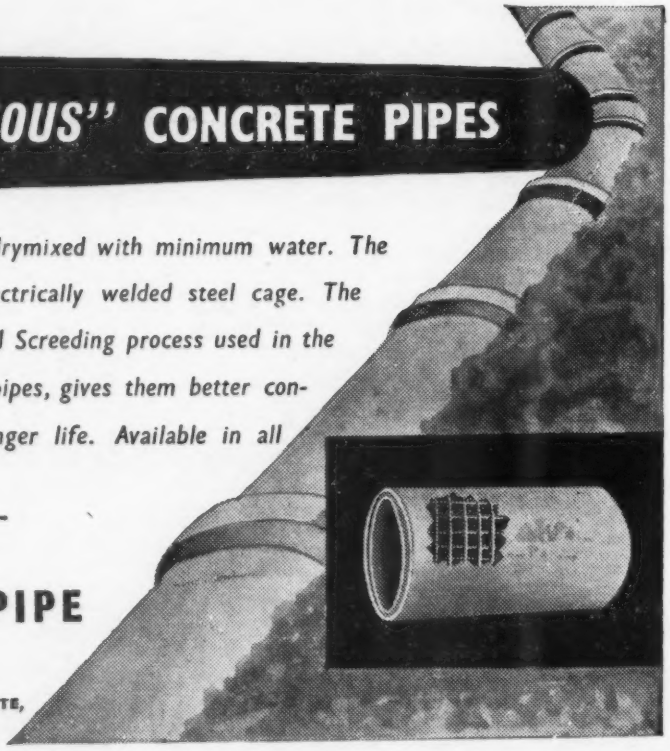

Calcutta Branch: **190/1, Rash Behari Avenue, Calcutta-29.**

Dr. H. L. Uppal
Director
and
S. R. Sehgal
Mathematical-cum-Statistical Officer
Irrigation and Power Research Institute, Punjab

Determination of Absorption Losses on Sabraon Branch and Kasur Branch Lower of Upper Bari Doab Canal

IT has been observed that high percentage of water let off at the head of a canal, seeps into the subsoil through unlined canal, branches and distributaries. It is generally ascertained that out of the total quantity of water that enters a canal at the head, 17% is lost by way of absorption and evaporation in the main canal and branches, 8% in the Distributaries and Minors and 20% in the water courses. This means that for every 100 cft of water received in the field, 182 cft of water is released at the head. It has been further found that even out of this 100 cft put in the field, only 70 cft is utilized by the crop plants and the remaining 30 cft is lost by way of absorption in regions below the root zone of the crops. So out of the 182 cft of water that enters a canal hardly 70 cft is utilised for crop production and the remaining 112 cft of water largely goes into the subsoil to add gradually to the rise of water table. Further due to lack of suitable drainage system, surface as well as underground, the subsoil water table goes on rising and induces waterlogging accompanied by all its evils of Thur and Sem. In order to have a quantitative idea of the amount of water which goes into the subsoil through main line branches and distributaries etc. a study has been instituted in the first instance to determine the extent and magnitude of absorption losses in respect of Sabraon branch and Kasur Branch Lower of the Upper Bari Doab Canal. This study is confined to the four months from November to February, evaporation losses being least in this period. It will then be extended to full year as well as to other branches, distributaries and minors of this canal system as well as others.

Absorption losses have been worked out by substracting the total supply delivered into all the distributaries of the particular branch of a canal during these four months from the total supply let into the branch during this period. The relevant statistics have been compiled from the gauge and discharge registers maintained in the U.B.D.C. offices.

The results of analysis in each case are given below:—

A: Sabraon Branch

(a) Sabraon branch which takes off from Kasur Branch Upper at Sathiali irrigates the tract which comprises of Jandiala Division in Upper Bari Doab Canal Circle. The data studied covers the period 1945-46 to 1957-58. Absorption losses thus worked out for the years 1945-46 to 1957-58, during the period November to succeeding February are given in Table I. The losses have been further expressed as percentage of total supply delivered into the Branch canal given in the same table. The following items have been investigated:—

(1) Magnitude and extent of losses.
(2) Relation between supply delivered into the canal and total absorption losses.
(3) Variation of losses from year to year.

Magnitude and Extent of Losses

It has been calculated that on the average 20 percent of supply delivered during the months November to February, is lost by way of absorption in respect of Sabraon Branch. The analysis has further revealed that daily mean absorption losses work out to 35.6 cusecs during the months November to February the average being worked out on the number of days in this period and not on the number of days

TABLE I

STATEMENT SHOWING TOTAL SUPPLY DELIVERED INTO SABRAON BRANCH FROM NOVEMBER TO FEBRUARY AND ABSORPTION LOSSES FOR THE SAME PERIOD

Years	*Total supply delivered into the canal (less escapage) (cusecs)*	*Supply deivered into distributaries (cusecs)*	*Total absorption (Cusecs)*	*Average daily absorption (Cusecs)*	*% absorption*
1945-46	23,187	19,590.5	3,596.5	29.97	15.51
1946-47	24,952	19,934.0	5,018.0	41.82	20.11
1947-48	35,220	27,257.0	7,963.0	65.81	22.61
1948-49	26,492	23,134.4	3.357.6	27.98	12.67
1949-50	26,050	22,219.9	3,830.1	31.92	14.70
1950-51	36,486	25,417.4	11,068.6	92.24	30.34
1951-52	23,256	18,271.3	4,984.7	41.20	21.43
1952-53	24,042	19,040.54	5,001.46	41.68	20.80
1953-54	25,558	21,294.36	4,263.64	35.53	16.68
1954-55	22,758	19,575.3	3,182.7	26.52	13.98
1955-56	44,007	35,488.42	8,518.58	70.40	19.36
1956-57	46,346	29,544.74	16,801.26	140 01	36.25
1957-58	38,803	32,164.43	6,638.57	55.32	17.11
			Average	53.88	20.12

canal was in flow. Daily quantity of water thus lost by absorption amounts to 30,75,840 cft during these months.

Relationship between supply delivered into the canal and Absorption Losses

Total supply delivered into the canal (less escapages) during the months November to February and figures of absorption losses for the corresponding period are given in Table I. and plotted in Fig 1. A persual of Table I clearly indicates that increase in supply delivered into the canal results in increase in absorption losses and vice versa. This has been further statistically verified by working out coefficient of correlation between total supply delivered into Sabraon branch and absorption losses. The correlation coefficient came out to be highly significant which confirms that increase in the supply delivered into the canal results in increase in the absorption losses.

GRAPH SHOWING PLOTTING OF TOTAL SUPPLY DELIVERED INTO SABRAON BRANCH (LESS ESCAPAGES) AND ABSORPTION LOSSES DURING NOVEMBER TO FEBRUARY FOR THE YEARS 1945-46 TO 1957-58

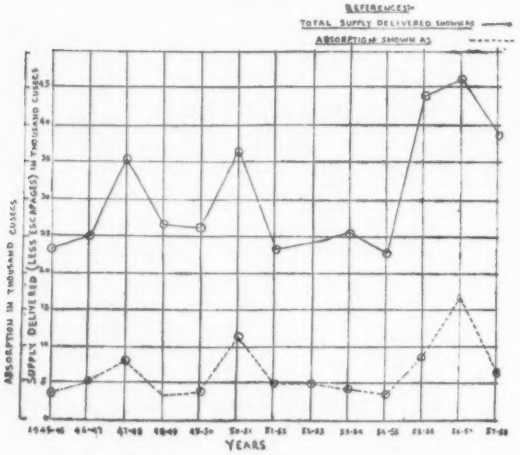

Fig. 1.

Variation of losses from year to year

A perusal of Table I will clearly show that

(1) There is a great variation of losses from year to year.

(2) Percentage absorption vary from 12.67% to 36.25% average being 20.12%.

(3) No significant trend towards increase or decrease in percentage absorption is evident from the data;

B: KASUR BRANCH LOWER

Kasur Branch Lower also takes off from Kasur Branch Upper at Sathiala and irrigates Jandiala Division of the Upper Bari Doab Canal Circle.

Magnitude and Extent of Losses

Figures of total absorption losses from November to February for the years 1945-46 to 1957-58 are given in Table 2 and plotted in Fig. 2. It has been calculated that an average of 18 percent of water delivered into this Branch during the months November to February is lost by way of absorption which slightly falls short of Sabraon branch. Daily mean losses in case of this Branch work out to 55.5 cs, the average being worked out on the number of days in this period and not on the number of days the canal was in flow. The average quantity of water thus lost by absorption works out to 47,95,200 cft.

Relationship between supply delivered into the canal and absorption losses

A perusal of Table 2 and Fig. 2 will clearly indicate that increase in supply delivered into the canal

GRAPH SHOWING PLOTTING OF TOTAL SUPPLY DELIVERED INTO KASUR BRANCH LOWER (LESS ESCAPAGES) AND ABSORPTION LOSSES DURING NOVEMBER TO FEBRUARY FOR THE YEARS 1945-46 TO 1957-58

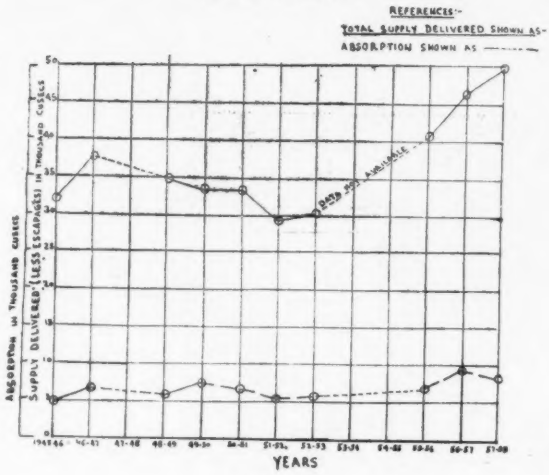

Fig. 2.

resulted in increase in the amount of absorption losses. This was further confirmed by working out correlation coefficient between total supply delivered into the canal during the four months, November to Feb. and amount of absorption losses in the corresponding period.

Variation of losses from year to year

(1) There is less variation in percentage absorption losses in case of this Branch as compared to Babroan Branch.

(2)- Absorption vary from 14.86% to 22.11% during the period considered, average being 18.23%.

(3) No significant trend towards increase or decrease in percentage absorption is evident from the data in this case also.

Further work is being continued.

Summary

In order to have a quantitative idea of the amount of water which goes into the subsoil through unlined canal, a study was instituted in the first instance to determine the magnitude and extent of absorption losses in respect of Sabraon Branch and Kasur Branch Lower of the Upper Bari Doab Canal during the winter months November to February. The study will be extended as to cover the whole year as well as to other canal systems.

TABLE 2

STATEMENT SHOWING TOTAL SUPPLY DELIVERED INTO KASUR BRANCH LOWER FROM NOVEMBER TO FEBRUARY AND ABSORPTION LOSSES FOR THE SAME PERIOD

Years	*Total supply delivered into the canal (less escapage) (cusecs)*	*Supply delivered into distributaries (cusecs)*	*Total absorption (Cusecs)*	*Average daily absorption (Cusecs)*	*% absorption*
1945-46	31,925	27,181.5	4,743.5	39.53	14.86
1946-47	37,500	30,805.0	6,695.0	55.79	17.85
1947-48		Data incomplete			
1948-49	34,572	28,763.0	5,809.0	48.41	16.80
1949-50	33,272	25,916.15	7,355.85	61.30	22.11
1950-51	33,160	26,327.35	6,832.65	56.94	20.61
1951-52	29,230	23,969.9	5,260.1	43.47	18.00
1952-53	30,195	24,693.7	5,501.3	45.84	18.22
1953-54		Data incomplete			
1954-55		Data incomplete			
1955-56	40,574	33,602.5	6,971.5	57.62	17.18
1956-57	46,153	36,860.5	9,292.5	77.44	20.13
1957-58	49,667	41,434.5	8,232.5	68.60	16.58
		Average		55.49	18.23

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Survey in River Valley Projects

SURVEYS occupy paramount place in the preparation of preliminary reports and in the construction of River Valley Projects. They supply the basic data for the choice of the site, the type of structures to be built, the quantity of materials involved in the structures, for preparing the construction programme and for the acquisition of lands for the Project. Accurate surveys for these purposes are therefore quite essential for the estimation of the cost of the Project beforehand and for the completion of the work within the stipulated cost and the scheduled target date without making any changes in the construction schedule as are being witnessed in many River Valley Projects under construction. Hence it becomes imperative after a project is mooted out to set up a separate department for this important task with a team of experienced and well trained men.

The following are the various kinds of surveys needed in a River Valley Project.

1. Location Surveys.
2. Sub-surface investigation Surveys.
3. Topographic Surveys.
4. Area capacity Surveys.
5. Reservoir Surveys.
6. Retrogression Survey.
7. Sedimentation Survey.
8. Surveys for anti-malarial measures.
9. Exploration surveys for Borrow Areas and Quarries.
10. Soil Classification Survey.
11. Silt Survey.
12. Surveys for estimating the quantities of materials for the Project.
13. Control Surveys.
14. Surveys for the daily construction work in the Project.
15. Surveys to ascertain the progress of work and to provide necessary data for costing.

The role which each of the above plays in the economic execution of the Project can be better appreciated by dealing each one of them in great detail.

Location Surveys

Great care needs to be exercised in fixing the alignments of the Hydraulic structures for the Project. A number of alternative lines has to be laid on the field before choosing the final alignment because a comparative study has to be made regarding the merits and demerits of each. Rarely do we come across with an ideal site wherein decision can be given on the spot at the mere sight as in the case of a deep narrow gorge having good abutments on the sides.

In the absence of such an ideal site it becomes absolutely incumbent to study a number of alignments before making the final selection. The argument applies with equal force in the location of canals, canal off-takes etc. It is essential to realise the paramount importance of this Survey work since it forms the first step.

Sub-Surface investigation Surveys

This survey is meant for ascertaining the nature of the foundation to be met with and the depth of different stratas of materials in the river bed; The full extent over which the hydraulic structures are to be founded should be explored in minute detail for the location of soft zones such as clay pockets, other materials having low bearing strength, springs, artesian wells, deep fault and fissure lines. The existence of these calls for special treatment for the safety of the structure. A detail survey should be made and foundation plan be prepared giving full information about the findings observed in the course of drilling operations. Omission or non-detection of any of these in the beginning will have a telling effect on the cost of the Project and will upset the whole programme of construction. This has been realised at great cost by many of the engineers working in the Projects.

Topographic Surveys

In order to prepare the designs of different units a correct picture of the site is to be presented to the designer. This needs accurate contour surveys both ground contour survey and if need be aerial contour surveys. These contours are to be drawn at every 5 feet intervals. This constitutes one of the main economic surveys that is to be done in every River Valley Project.

Area Capacity Surveys

This is necessary to fix up the economic height of the structure so as to arrive at minimum submergence of the useful land and the maximum possible capacity of the reservoir. A number of contours has to be laid out and areas calculated. Graphs should be drawn connecting (1) elevation (height and area of submergence, and (2) capacity and height. The point of intersection of these two curves gives the economic height of the dam to be built. Hence this survey brings out great economy in the overall cost of the Project.

Reservoir Surveys

The Reservoir Surveys are meant (1) for demarcating the periphery of the high water line in the reservoir for acquisition of lands which come under submergence (2) to fix up the boundary of the normal pool of the reservoir so that the area between the high water line and the normal water line in the reservoir can be leased out for irrigation in case of dire necessity, (3) to fix up the reference monuments and bench mark pillars along the section lines run in the river bed from the dam upto the tail end of the reservoir at intervals of about every ½ mile parallel to the Dam for ascertaining the capacity of the reservoir and accumulation of silt deposit at regular intervals. These section lines are to be laid as close as possible at the tail end of the reservoir where the depth is shallow and should cover up all the nallahs within the high water line, (4) marking out irrigable areas within a distance of ½ mile around the periphery of the high water line for the purpose of preparing schemes for lift irrigation from the reservoir in case of failure of rains when water is required for the maturity of the crops.

Retrogression Survey

Surveys are to be undertaken downstream of the dam along the course of the river upto a certain length twice a year once before the monsoon and then after the monsoon in order to ascertain the extent of erosion that may likely to take place both in the bed and in the banks. This survey will provide sufficient clue for the necessity of taking up protective measures downstream of dam in order to prevent the retrogression of levels.

Sedimentation Survey

This survey is required to be conducted in the reservoir once in every five years in order to estimate the inflow of silt into the reservoir. This will help to take up the measures required for increasing the life of the reservoir.

Surveys for Anti-Malaria Measures

Malaria and irrigation go hand in hand. With the undertaking of irrigation projects it becomes quite essential to take up anti-malarial works. The anti-malarial engineering measures adopted in the case of reservoirs is to fluctuate the water level in the reservoir and thus provide what is called anti-malarial surcharge. The area upto this surcharge level should be deforested. Surveys should be done to mark out the limits along the shore line for the deforestation work and the acreage of areas to be cleared of trees and shrubs are to be found out. This clearance is also required for fish culture which is one of the benefits claimed for the River Valley Projects.

Exploration Survey for Borrow Areas and Quarries

After the site is chosen and the project is sanctioned it is the primary task to carry out the surveys for the materials of construction within the economic haul distance. Especially in the construction of Earth Dams the design depends on the properties of the materials available locally. The areas in the vicinity should therefore be examined both for the suitability of the materials and for the quantity available. The zones should be demarcated for different quantity of materials. An extensive survey should be undertaken to fix up the Borrow area and a programme of tapping these zones should be prepared. Quarries for rocks for aggregates and for pitching work must be explored and plotted on the location map. Any delay in undertaking this work or mistakes in the selection of these will cause bottlenecks in the progress of work and hence to the increase in cost.

Soil Classification Survey

This is the other economic survey which should be done in every irrigation Project. The soils in the area commanded by the canal system in the irrigation project should be surveyed and classified for determining the crops to be grown and for fixing up the crop pattern. The crop pattern is necessary to arrive at the water requirements and subsequently for the design of the canals. The importance of this survey for the economic design of canals is being realised by the Irrigation Engineers and is undertaken in all the Projects.

Silt Survey

Surveys must be undertaken to have idea of the inflow of silt in the reservoir. A rough estimate of this can be had by measuring the depth of silt which gets deposited in the area near the upstream toe of the dam during the years of construction. These surveys will throw sufficient light on the problem and will provide very valuable data for design purposes.

Surveys for Estimating the Quantities of Materials involved in different Units

A thorough pre-knowledge of the (1) quantity to be excavated for the foundations of structures (2) earthwork for embankment (3) materials for masonry

work and slope protection (4) and concrete in the project is essential to decide in the beginning whether the work is to be completely mechanised or to be partly mechanised or to be done by manual labour as the conditions satisfy the rules laid down by the plant and machinery sub-committee. The information is also necessary for determining the size of the construction plant to be ordered and for planning the construction plant. This gives the basic data for preparing the construction schedule and the schedule of materials for the smooth execution of the Project. Before calling for tenders when the work is to be given on a contract the exact quantities of different items works must be known earlier. To estimate the quantities correctly longitudinal sections and cross sections along the alignments of different units in the project should be taken. If the section are not taken sufficiently or if they do not cover up every details such as depressions and change of elevations and other important existing topographic features a great difference will be found during the course of construction causing many difficulties. This mistake committed in the earlier stage will upset the planning and will bring about great delay in the completion of the work as in some cases it calls for taking fresh sanctions issuing new work orders, calling again for fresh tenders since the amount exceeds the sanctioned estimate. Hence to avoid these troubles proper survey should be done and quantities should be accurately estimated.

Control Surveys

To control the work during the period of construction it becomes incumbent to establish Base Lines, co-ordinate points, chainage points, reference monuments, bench mark pillars and axis points in such places where they will not be disturbed by day to day work. Before the construction is to start the area of construction should be marked and all other informations to be provided by survey work should be furnished for the rapid and easy construction work. Without the aid of these reference monuments, bench marks, and other points it will be difficult to control the day's work in order to see that the construction is done as per the drawing.

Surveys for the daily Construction Works

It is quite essential to see that the profile of the structure under construction is maintained properly as per the lines shown in the design drawings.

For this purpose the slopes of the structures have to be checked up daily and slope points (toe points) should be given for every layer in the case of Earth Dam and for every lift in the case of concrete dam. Positions for the reinforcements and other embeded parts which go into the Concrete Dam and Earth Dam should be carefully marked. The points for curves and other geometrical shapes provided in the structures and to be given daily as the height is raised. The various zones in earthen embankment should be demarcated regularly with the commencement of each layer. Levels are to be taken daily. Shuttering work for each lift should be checked up for proper alignment and maintenance of correct slopes. Alignments need to be given and checked up often. Various other informations required for construction have to be given by surveyors daily. The surveyors and the survey staff should always be vigilant and must have their eyes glued on to the drawings and construction activity so that the construction follows the drawings in its entirety. If this is not done there will be heavy wastage of materials and involves extra work of removing the excess of materials laid on the slopes. If the surveyors' work for the day on the embankment is not heeded to by the construction men, ultimately it will tell both on the quality of the work and the cost of the construction. Surveyors thus play a great role in the daily construction activity.

Surveys to ascertain the Progress of Work and to provide necessary and sufficient Data for Cost Analysis

Now every multipurpose River Valley Project has been given the directive to submit the progress of work in the project at regular intervals and to maintain and work out the cost of each item of work done as per the reference and clauses laid by the rates and cost committee. To furnish this information the progress of work done in each unit in the Project should be measured at regular intervals, say, weekly. The Surveyors should run lines of levels and calculate the quantities of materials laid in the structure. A visual or graphical progress chart should be prepared and filled in regularly indicating the progress at any time. Studies are to be made regarding the performances of machineries and progress of other works, input and output of materials. Only the quantities thus calculated by running levels and taking cross sections by surveyors belonging to an independent section in the project can be considered as the proper basis for costing. It is only the surveys section which can furnish the relevant data for the costing department. With the help of the progress found out, various other charts necessary to present a clear picture and necessary information at a glance can be prepared for a proper study and examination at any stage by any one.

Thus one can see the role these surveys and the surveyors play in the River Valley Project from its very inception when the investigation starts to the final completion of the work. Their necessity is felt at every stage. From the above it can be realised on all hands that for the execution of River Valley Projects as per the estimated cost and the target period the surveys enumerated above should be undertaken. Due to the great importance and the magnitude of this work it is but fair to have an independent section in

(Continued on page 10)

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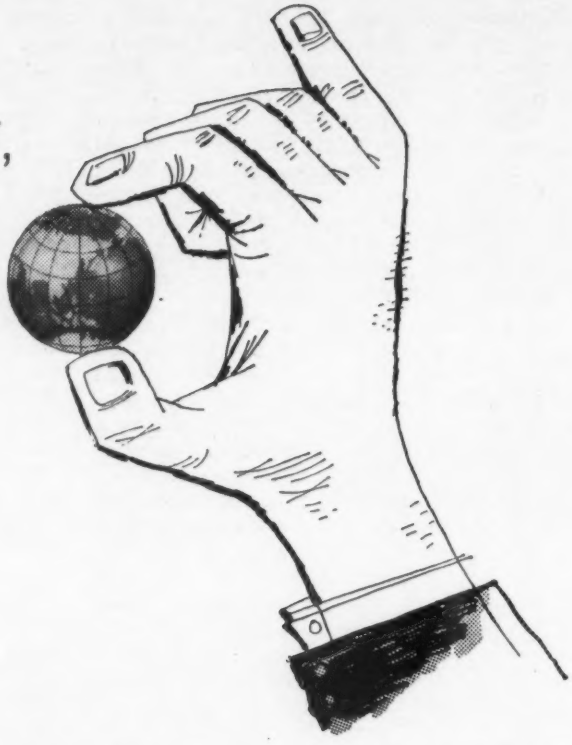

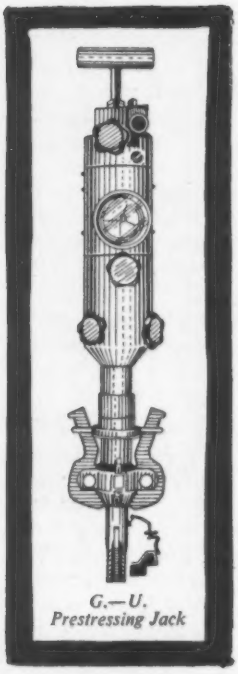

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Operation of DVC Reservoirs: A Brief Review

The following is a brief review of operation of DVC reservoirs during the monsoon months July to October 1960, prepared in the Reservoir Operation and Control Office of the D.V.C.

Different Purposes to be served and the General Approach

THE different purposes to be served by the reservoirs were flood control, release of flushing doses for maintenance of river regime in lower valley, water supply for kharif irrigation, hydel power generation, water supply for industrial and domestic uses, foreshore farming, fishery development, malaria control and storage of water for dry period release.

The flood control purpose was served by keeping the portion of the reservoir capacity above monsoon storage level (equal to 1.05 million acre-ft. in the four reservoirs together) empty at all times so that the excess flood inflow above the safe discharge could be held back temporarily and released later when the flood recedes.

Provision for release of flushing dose was made by earmarking 100,000 acre-ft. of storage capacity at Panchet between R.L. 402 and R.L. 410. This provision was for July and August only and after 31st August the capacity between R.L. 402 and R.L. 410 was to be filled up as part of monsoon storage.

Sufficient water was to be filled up in each of the reservoirs so that the water level would reach monsoon storage levels before the rainy season came to an end. Release below dams was to be adequate at all time to meet the requirements of kharif irrigation and of industrial and domestic uses. The excess water was to be so released as to generate maximum hydel power. The fluctuation in the reservoirs was to be such that it would not adversely affect foreshore farming and malaria control operations. In the interest of fishery development it was desirable to avoid drawing the reservoirs below dead storage level.

Guide for flood control operation

In the comments received from West Bengal Govt. authorities it was pointed out that the lower trans-Damodar-Mundeswari area is affected even when the discharge exceeds 1 lac cusecs and to keep the maximum outflow to 1 lac cusecs or even less will be a great boon for the lower valley. They recommended that the outflow from the dams may be limited to 1.2 lac cusecs till the inflow exceeds 4 lac cusecs when the outflow may be increased to 1.6 lac cusecs; and this rate is to be maintained till whole of flood reserve is used when the outflow should be balanced with inflow. This was done with a view to save the trans-Damodar area from flooding as far as possible. Moreover, before releasing any heavy discharge clearance was obtained from the West Bengal Govt. authorities regarding congestion in the lower valley. Even with the reduced discharge of about 100,000 cusecs there were reports of breaches in embankments of Amta channel during the month of August. Therefore, the procedure for operation was further modified towards end of September as shown below:—

(i) Limit the outflow to 80,000 cusecs till 400,000 acre-ft. (about 50%) of flood reserve is used.

(ii) Limit the total outflow to 120,000 cusecs while using flood reserve between 400,000 to 600,000 acre-ft. (50% to 70%).

(iii) Limit the total outflow to 160,000 cusecs while using the flood reserve between 600,000 to 858,000 acre-ft. to (70% to 100%).

(iv) When all the flood reserve of 858,000 acre-ft. is fully utilised, if inflow is more than 160,000 cusecs, then balance outflow with inflow.

The provision of limiting the outflow to 80,000 cusecs till 50% of the flood reserve is used up, would ensure avoiding occurrance of breaches in the embankments of the Amta channel in the cases of small floods which occur quite frequently.

Reservoir Levels

Water was released from the dams primarily with a view to generate maximum hydel power and also taking care to see that the kharif irrigation demand was met in full. The excess inflow was stored to build up reservoir levels. All the reservoirs were at the desired monsoon storage level by end of August. The maximum flood levels reached during the season at

the four reservoirs were: Tilaiya El. 1211.2, Konar El. 1397.9, Maithon El. 487.2 and Panchet El. 419.3.

Rainfall

Daily rainfall was recorded at 66 raingauge stations within the valley area including the irrigated area. The average rainfall over the valley during the monsoon season (June to October) 1960 was 41.5 inches which is slightly less than the normal (44.8 inches).

Runoff

Using the information regarding outflow and rise or fall in reservoir levels, the daily inflow into the reservoirs were computed. Total runoff from the catchment upto the dams (6,664 sq. miles) was 5.46 million acre-ft. equivalent to 15.4 inches.

Flushing Doses

To maintain the river regime and save the channel from deterioration so that its flow carrying capacity is not reduced, the channel was flushed with concentrated dose of flow by temporarily withholding water in the reservoir and releasing as a comparatively heavy flow. The doses provided were 3 in August, 3 in September and 1 in September-October. The peak discharge for these occasions varied from 104,000 cusecs to 38,000 cusecs and the duration from 265 hrs. to 50 hrs. The rate of discharge and the duration of these flushing dose releases depend upon the condition of reservoir levels and the inflow pattern during that period. Assuming that releases in excess of 35,000 cusecs would substantially contribute towards the maintenance of river regime in the lower valley, the position during 1960 monsoon was as follow:—

	without dams	*with dams*
Duration with release in excess of 35,000 cusecs	18 days	23 days
Volume of flow during the period when releases were more than 35,000 cusecs	2.5 m. ac-ft.	2.7 m. ac-ft.

As to what effect these flushing dose releases have produced on the river channel in the lower valley remains to be studied after receiving cross-sections data which are being collected.

Volume of Water used for Kharif Irrigation

Water was provided for kharif irrigation for an area of about 8,50,000 acres according to the bi-weekly indents received from the West Bengal authorities. The total release through the hydel units throughout the kharif irrigation period was more than the water indented for, and therefore, no difficulty whatsoever was experienced in meeting the demand. The quantity of water indented for irrigation was equal to 11,98,000 acre-ft. against which actual withdrawal into the canals was 11,22,000 acre-ft. In this connection, the following information regarding kharif irrigation below Durgapur would be of interest:

Year	*Area irrigated — acres*	*Total volume of water withdrawn into the canals at Headworks — acre-ft.*	*Total delta — inches*
1956	1,97,000	3,85,000	23
1957	3,29,000	6,33,000	23
1958	4,29,000	9,21,000	26
1959	6,19,000	7,10,000	14
1960	8,50,000	11,22,000	16

The above table shows that appreciable economy is being exercised in the use of water from year to year which means that the wastage is being considerably reduced.

Volume of Water used for Power Generation

During the monsoon period, the releases from Maithon and Panchet reservoirs were made with a view to generate maximum power keeping in view that the combined release from the two dams was sufficient to meet the requirement of kharif irrigation. Practically, throughout the whole of monsoon period (July to October) both the power houses were running continuously. In this connection, the following information regarding hydel power generation during the monsoon period (July to October) would be of interest.

	Volume of water passed through hydel units 1000 acre-ft.			*Hydel energy generated — million kWhrs.*		
	Tilaiya	*Maithon*	*Panchet*	*Tilaiya*	*Maithon*	*Panchet*
1952	—	—	—	—	—	—
1953	20	—	—	0.02	—	—
1954	38	—	—	1.66	—	—
1955	102	—	—	4.68	—	—
1956	1	—	—	0.03	—	—
1957	42	—	—	1.99	—	—
1958	19	591	—	1.17	60.37	—
1959	172	1136	582	10.13	112.18	43.16
1960	86	754	1443	4.94	77.48	98.32

Water withdrawn for Industrial and Domestic Uses

Nearly 500 cusecs of water was withdrawn for industrial and for domestic uses by the agencies located alongside the rivers, out of which 150 cusecs were in the river reach between Konar and Panchet and the remaining 350 cusecs between Maithon/Panchet and Durgapur. In this connection, the following information of actual withdrawal (as per field survey) for industrial use during the different years would be of interest.

Year	*Reach between Konar and Panchet*	*Reach between maithon/ Panchet and Durgapur*	*Total*
1951	20	25	45
1956	41	42	83
1959	85	67	152
1960	150	350	500

Extent of Flood Reserve used

Whenever the reservoir level exceeded the prescribed monsoon storage level and when the inflow into the reservoir exceeded the capacity of the hydel units, flood control operation was started. During such operation there would be some rise of water level if the release from dams was less than inflow. During the period under review (July to October) Maithon reservoir reached a maximum level of 487.2 and Panchet 419.3. In terms of flood storage used, it was at Maithon 136,000 acre-ft. (44% of the flood storage capacity between 480 and 495) and at Panchet 158,000 acre-ft. (29% of the flood storage capacity between 410 and 435). The combined flood storage used for flood regulation was 294,000 acre-ft. i.e., 34.5% of the total available flood reserve of 8,58,000 acre-ft. The maximum flood peak of 350,000 cusecs at the dams occurred during the monsoon period and this was moderated to 92,000 cusecs below dams. In this connection, the following information regarding the extent of flood reserve used corresponding to maximum flood of each year and the corresponding reduction in peak flow would be of interest.

	Extent of flood reserve used – 1000 acre-ft.					*Maithan & Panchet together – 1000 cusec*	
Year	*Tilaiya*	*Konar*	*Maithon*	*Panchet*	*Total*	*without dams*	*with dams*
1957	42	31	137	8	218	330	260
1958	40	67	310	450	867	600	190
1959	50	20	312	484	866	623	288
1960	11	6	136	158	311	350	92

Water Balance Account

To sum up, the position of water balance account during the monsoon was as follows:—

Total yield upto Durgapur	6.07	million acre-ft.
Quantity stored in the reservoirs	0.66	— do —
Withdrawn for kharif irrigation	1.12	— do —
Withdrawn for industrial & domestic use	0.12	— do —
Escaped into the river below Durgapur	4.17	— do —
Quantity which passed through hydel units	2.28	— do —

Flood Warning to downstream interests

DVC has a system of giving flood warning in advance to the parties located downstream of the dams in the event of high releases from the dams on payment of certain charges. Advance notices were issued to the agencies who enlisted for the purpose on all occasions. In addition, the district authorities were given the warnings free of charge. Also, the I. & W. Department, West Bengal Government, have an arrangement of hoisting red signal lamp as a measure of flood warning to the people of some localities near Burdwan. A suggestion has been made that similar arrangements may be extended to other localities also where river crossing and other activities have increased recently due to increased tempo of industrialisation in this region.

Time of travel of releases from Dams

As the releases from the dams were controlled, the time taken for the water to reach different points downstream could be found out by alerting the downstream observers in advance.

TIME OF TRAVEL CORRESPONDING TO PEAK STAGE IN HOURS

Panchet to	
Raniganj	8 to 10 hrs.
Durgapur	13 to 14 hrs.
Rhondia	18 to 20 hrs.
Jujuty	30 to 35 hrs.
Edilpur	33 to 38 hrs.
Palla	40 to 45 hrs.
Jamalpur	45 to 50 hrs.

Reports of Flooding

In the month of September some newspapers reported that "the embankment of the Madaria canal had also been breached but the bund was repaired the next day before any considerable damage was caused." The matter was looked into and it was reported that the Amta channel has silted up to such an extent that even with comparatively low discharge high levels result in Amta channel. It means that the releases from dams should be limited to less than 100,000 cusecs in order to avoid breaches in the embankments of Amta channel. Alternatively, it is for

consideration whether the channel may be closed altogether at its head near the bifurcation point at Begua as recommended by the AWR Committee.

In another newspaper report it was stated that "as a result of the release of water from the Panchet dam by the D.V.C., about 14,500 acres on both sides of the Darakeswar in Arambagh Subdivision were flooded recently." At this time the maximum release from dams was about 40,000 cusecs only. How this rate of discharge caused extensive flooding as reported is not understood.

A third report published on 1st October 1960 stated that "the rising level of the Mundeswari in Hooghly—1½ ft below the danger mark on Friday noon—was causing anxiety to the district authorities —the Damodar near Burdwan, which had a heavy shower on Friday morning, was four feet below the preliminary danger level. The discharge at Durgapur barrage was said to be 100,000 cusecs, 250,000 cusecs being the level requiring caution in the lower reaches—". It is not known what is understood by "the danger mark" in the Mundeswari. The river has no embankments and so the question of breaches does not arise. Presumably the danger is of spilling. The discharge capacity of Mundeswari is often mentioned as 70,000 cusecs. When there is tide lockage it would be much less. In such an event spilling may be unavoidable even with small discharges on account of the deteriorated condition of the river channels.

Representation for Flood Irrigation

A representation was received from the Sadipur Samabay Krishi Unnayan Samity Ltd., village Sadipur, Burdwan, requesting that if arrangement for supply of 2½ lakh cusecs water from Damodar River is made for 36 hours, their area can be well irrigated and the inhabitants may avoid the state of starvation which they have been facing for the last few years. This problem was gone into and it was found that in order to help this area, if we release a flushing dose of about 1½ lakh cusecs for 36 hours, we will only be inviting more complaints from the people of the trans-Damodar area lower down, which is apparent from what has been mentioned earlier.

Suggestions from Flood Co-ordination Board, Hooghly

The Collector of Hooghly has made a suggestion that gauging stations be established on the rivers Mundeswari and Dwarakeswar; and that releases from DVC dams be adjusted keeping in view the level of water in the Dwarakeswar. This raises two questions, one of organisational jurisdiction and another of technical feasibility. Regarding the first question, the DVC takes observations in the rivers above Surekalna only. The area referred to by the Collector of Hooghly is below Surekalna. Further the river Dwarakeswar happens to be outside the Damodar Valley. Therefore, the organisational jurisdiction as to whether DVC should take these field observations or West Bengal Government is a matter to be decided first. As regards the second question, it is recognised that release from dams should be adjusted to provide maximum protection from flooding of areas in lower valley. For this purpose an arrangement was made during the 1960 monsoon period, to obtain clearance from Chief Engineer, I. & W., regarding the condition of congestion in the lower valley before releasing heavy discharges from dams. The fact that there are still some complaints from lower valley shows that this question should be studied in greater detail. It is reported that since the construction of DVC dams, the frequency of floods is reduced, particularly in the early months of the monsoon period, as a result of which vast extent of areas in the flood plains of river channels have recently been reclaimed by the local people for purpose of cultivation. These areas will be inundated whenever there is a heavy flow, even though such discharge may be less than what was previously considered as safe discharge. Those who are thus affected, naturally kick up a hue and cry that the DVC has flooded them. This shows that the uncontrolled encroachment into the flood plains will result in recurring complaints in the future. Therefore, timely co-ordination by the District Authorities in this regard is very necessary. A general examination of the maps of this region seems to indicate that the time of travel of Dwarakeswar water to reach trans-Damodar area is less than the time of travel of water released from DVC dams to reach trans-Damodar area. This means that it may not be possible to effectively control the releases from dams on the basis of water levels in Dwarakeswar. In that case the solution appears to lie in putting up some detention reservoir on the Dwarakeswar river.

Continued from p. 35

SEMINAR ON ENGINEERING EDUCATION IN.....

be appointed as heads of engineering projects and industries.

10. Introduction of a system of in-training schemes in industries in order to develop the know-how of technicians at the diploma level.

The Seminar concluded with a vote of thanks to Dr. Khosla, Dr. K. L. Rao, the Chairman of the Discussion Sessions and the sponsors and all the participants.

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Seminar on Engineering Education in Eastern India: A Report

AN interesting Seminar on the subject of "Engineering Education in Eastern India" was held on December 27 and 28, 1960 in Calcutta. Dr. A. N. Khosla, Member, Planning Commission, an eminent engineer, formely Vice-Chancellor of the Roorkee University, inaugurated the same, and Dr. K. L. Rao, President, Institution of Engineers (India), and Member, Central Water and Power Commission, presided. The following gives a brief report of the Seminar, a fuller version of which will be published, together with the papers, in a special number of this Journal.

The idea of the Seminar originated with this journal, as its editors were considering how to celebrate its Tenth Anniversary in a befitting manner. The sponsors of the Seminar were the Jadavpur University, Bengal Centre of the Institution of Engineers, India, and this Journal.

Twenty-one papers were submitted to the Seminar.

In a specially erected pandal at the premises of the Jadavpur University, æsthetically decorated, the inaugural function took place on the 27th December. **Dr. Triguna Sen,** the Rector of the Jadavpur University, and Chairman of the Organising Committee of the Seminar, welcomed Dr. Khosla and Dr. Rao and other leading engineers present on the occasion. In the course of his speech, he said: "I would like to sound a note of warning. Engineering Education will no doubt assure material progress of the country, but let us not purchase material progress at the cost of spiritual progress which India has treasured since the days when the sages sang the Vedas."

INAUGURAL ADDRESS

Dr. A. N. Khosla read out his prepared speech which gave a brilliant review of the progress that India is making in the field of technical education and of the various policy decisions that are being taken at the highest level in this respect.

He said, among other things, that talented and first-rate men were not being attracted to the profession of teaching of engineering in India. There was a serious shortage of teachers in engineering institutions in the country, the percentage varying from 10 to 40, despite the fact that a good number of them are only "second rate". Poor salary scales compared with the income of professional engineers and want of security in service were reasons which explained this rather sad state of affairs. Dr. Khosla emphasised the importance of admitting only the most meritorious students to engineering institutions to eliminate the chances of failures in examinations. India, he said, was badly in need of engineers and technicians and it was difficult to visualize an excess of engineering personnel in the country in the forseeable future. Despite the shortage of engineers, he regretted they were often called upon to do work which should be done by technicians or clerks. To promote engineering education, Dr. Khosla contended, co-operation among the educational institutions, the different departments of the Government and the industry was essential.

PRESIDENTIAL ADDRESS

Dr. K. L. Rao, in the course of his fascinating presidential address, remarked that engineering is a major cultural force. The history of engineering and that of civilisation are more or less the same. He said that before technology can advance it is necessary that people must get an idea of what science can achieve. The general background of education in terms of the achievements of sciences among the people is essential. While fully supporting the expansion of engineering education in the country, he uttered a note of caution for preserving the quality in teaching. He felt that before engineering can deliver the goods in the country, engineers must have a high position in society. Today even in engineering industries the administrators are on top of the engineers. This trend has gone to such an extent that even the Chairmen of State Electricity Boards are non-engineers. He contrasted this with the experience in England and said that it is a great national waste of efficiency, and duplication.

Dr. Rao was of the opinion that Universities should teach only the basic principles in engineering, as, every branch of engineering is changing so fast that it is not possible to learn the latest techniques. Higher study in engineering should mean obtaining a good grasp of the fundamentals. He supported the idea of

Dr. A. N. Khosla delivering the inaugural speech.

senior engineers in industry to give some of their time to teaching also. Dr. Rao bemoaned that there was hardly any original thinking among many engineers today; they are only dealing with files and more files. In the Bureau of Reclamation, on the contrary, he pictured, in constant to our research institutions, engineers have ample time for thinking. There is hardly a good technical library in this country, for we have not yet begun to value books. Books mean new ideas. If we want to put forward fresh ideas we must "live with others" through books. Dr. Rao again commented that although we have spent over 1,000 crores of rupees on irrigation and power since independence, we have hardly contributed anything original to the science of engineering. What is produced in our country are "standard engineers". He was totally against standardisation of engineering education. As in the West, degrees should be given for original research in the post-graduate course, and wider opportunities should be created for research work. Emphasis should be given on the study of the basic sciences. "Science is a language of nature and engineers must master nature." Therefore, in order to be good engineers they should be "soaked in the sciences", concluded Dr. Rao.

Mr. K. Barua, Chief Engineer, P. W. D., Assam, then addressed the gathering and welcomed the idea of the Seminar. **Prof. R. G. Hennes,** Guest Professor in civil engineering in the B. E. College and **Prof. J. G. Van Vleet,** Guest Professor in mechanical engineering in the B. E. College, and co-ordinator TCM, University of Wisconsin Programme, also addressed the gathering. **Mr. P. R. Ahuja,** Chief Engineer, Floods, C.W. & P.C. stressed the need to teach the students through the project method and case studies of live problems rather than remain dependent entirely on text-books. He also thought that discipline and esprit de corps among engineers are extremely necessary. **Mr. Akshoy Bose** thought there was much scope for improvement in the syllabus of humanities in technical education. He also referred to corruption among engineers and stressed the need to teach ethics to the students. He condemned the competition between colleges to produce more first class graduates, and characterised the present-day engineers as a "bit money-minded"

Mr. S. Bandyopadhyaya, the Chief Engineer, Construction Board, West Bengal, gave a vote of thanks to the eminent speakers and leading engineers and educationists present with a beautiful and thoughtful little speech.

THE SECOND DAY'S SESSION

The second session of the Seminar took place at the premises of the Institution of Engineers in the morning of the 28th with Prof. N. N. Sen Gupta, Principal, Calcutta Technical School, in the chair.

The session commenced with an address by **Prof. S. N. Bose,** the National Professor for physics. Prof. Bose referred to the Japanese experience in modernising itself in the field of technology. He reminded the audience how only a few decades back Japan used to produce only consumer goods and it has now changed itself to machine-building and is exporting the same to many countries in competition with the West.

Prof. Bose said that it was vital that "engineering be not considered as an isolated, compartmentalised set of problems but as a part of the general scientific problem". He felt that the "engineer is not a technician but a creator".

The session then started with the moving of the papers.

Mr. D. Mookerjea, Chief Engineer, Kosi Project, who could not be present in the Seminar, pointed out in his paper entitled "Country needs quality engineers". that so long the idea behind training of our engineers was to man subordinnate posts in military engineering services and in the P.W.D. But now the task is much bigger as we have to make up the leeway between our country and the developed countries in the West. Our boys have to be taught machine design and their manufacture, planning and processing of basic industries etc. The students are not only to study existing techniques but also to improve upon them. For all these reasons more emphasis should be laid on the fundamentals of a problem or a theory. But how can this be done with ill-staffed and under-staffed institutions? The present emphasis on quantity rather than quality is a retrograde step.

He said that the State will have to treat the engineering and scientific services with some special favour to attract the best brains, and an excellent band of teachers will have to be provided as initial steps.

Mr. B. Maitra, Director, W. B. River Research Institute, in his thought-provoking paper on "Engineering Education", defined the aim of education as

to make the recipient self-sufficient in the sense that he can then continue to educate himself with all the problems that he faces. He would not be limited by the given techniques but can attack new problems in new ways. Mr. Maitra then discussed at length the need to lay great stress on the teaching of the fundamental subjects like mathematics, physics and chemistry. He has suggested a scheme of the division of time that should be given in the teaching of different subjects. He thought that the great success of Ecole Polytechnique of Paris has been mainly due to its stress on the fundamental sciences. He also referred to the comments of S. P. Timoshenko, a leading engineer of the Soviet Union regarding the changing educational policies in that country in the earlier period after revolution.

Dr. G. P. Chatterjee, Chief Metallurgist, Hindustan Steel in his paper entitled "Fundamentals of Engineering Education with particular reference to Speed and Quality of Industrial Development in India", said that India was faced with the dual task of promoting a large magnitude of development and a large speed of that development. This was equally true of engineering education. But it was not merely these scalar tasks but also the vector one, namely, of providing direction, that was important. Therefore there was the danger of losing quality of production.

In the opinion of Dr. Chatterjee, two most vital elements in undertaking this multiple task are:

i. The equipment and the atmosphere

ii. Dedicated and talented teachers.

The first condition may be fulfilled by more investment but the second one is more difficult to provide. He thought that some planned effort in this direction is necessary although there are some obvious limitations.

In the absence of the required number of good teachers, he thought the syllabus of study should be carefully framed. He wished to lay great stress on study of fundamentals of each branch of engineering instead of on the details. The talented teachers in each field may be asked to hold seminars and give lectures in different institutions. The idea was to promote training to think. He further suggested reorientation of the examination pattern, stressing on putting questions which would require basic thinking rather than cramming of details.

The author felt that teaching at Polytechnics are being seriously neglected. As regards the absorption of engineers in services he felt there is lot of wastage which the country could ill afford.

Mr. B. Chaudhury in his paper on "Remodelling of Technical and Engineering Education", thinks that the institutions must not attempt to train men as full-fledged engineers but rather should aim to give a broad and solid foundation. For this there is need to remodel the curricula. He notices that the entrants to these institutions are too immature to receive insruction in the scientific and technical subjects and that is one factor to explain the large percentage in failures. The change in the medium of instruction is also one reason. He pleads for more stress on day-to-day sessional tutorial and assignment work.

He thinks the grade of pay of staff is too poor to attract proper teachers. For practical training of graduates, the Government should arrange with the industry and the professions. A liaison officer at the institutions may help both the students and the industry in the placement of graduates.

He suggests the formation of an all-India Society of Technical Education.

Mr. P. K. Ghosh of West Bengal State Electricity Board, in his paper entitled "Engineering Education problems in the years ahead" is of the opinion that teaching of mathematics as well as laboratory experiments are equally important. But the laboratory experiments need to be reorientated in the sense that deviation from expected results should be more closely studied.

The engineers should also be given management courses.

He then discusses the problem of shortage of teachers and makes some suggestions. He also thinks that with better co-ordination between Government, industry and educational institutions, there will be less acute shortage of engineers in certain fields than is now being experienced.

He discusses the language problem in imparting education and strongly feels that from a practical point of view stress should continue to be given on English.

Dr. K. C. Roy Chowdhury of Jadavpur University in his paper entitled "Recent Trends in Chemical Engineering Education in India" surveys the position of chemical engineering education in India and other western countries. He has given an instructive Table at the end of his paper, comparing the weightage given to each group of subjects in the under-graduate course in chemical engineering in such leading institutions as Carnegie, Purdue, MIT, Karlsruhe and the all-India Board. This would be a good material for reference while discussing other fields of engineering also.

Mr. Amitabha Bhattacharya of Bengal Engineering College in his paper "Engineering Research collateral to Teaching" discusses how research has a great bearing on the education and development of the student, of the continued freshness of the teacher, and of the usefulness of the small industry, and how it helps the researcher to grow into maturity.

Dr. N. N. Roy of the Jadavpur University in his paper on "Higher Engineering Education in India" was of the opinion that the reason for lack of sufficient interest in post-graduate study at the Indian universities in science and engineering is mainly due

to the absence of actual research atmosphere and want of encouragement not so much due to the inadequacy of equipment. But now foreign universities are contemplating putting some sort of restrictions on admission of students of other countries. It is, therefore, time we in India gave adequate recognition to post-graduate work in this country.

Dr. Roy listed the following particular requirements for research work: Research atmosphere, background knowledge, proper guidance, equipment and appliances, space, adequate funds, library facilities, co-operation among industrialists and universities, encouragement from the authorities, and, finally, initiative. He thought that the Indian student is more eager to obtain a degree than to learn. He was also of the opinion that a professor competent in one subject is wrongly asked to teach in several—a practice which should be remedied.

He was also keen that English should continue as the medium of higher education.

Dr. B. N. Chanda and Mr. M. Sen Gupta of Jadavpur University felt that the foundation of engineering may profitably be laid in the undergraduate years by attractive integration of the humanities and social sciences with physical science, mathematics and engineering. The paper discussed the problem of engineering education under the following heads: new entrants, curricula, examination and teachers.

They felt that entrants from the science stream and the technical stream do not have the same background in terms of the basic sciences and therefore, difficulty is felt in teaching both the groups at the same time. It was their opinion that emphasis be given on providing a sound background in basic sciences and fundamentals of engineering. But after the 4th year those who would continue further studies and research as post-graduates should have a different type of course in the 5th year than those who would go to industry and the profession.

The authors also felt that the system of examination should be reorientated to make the student more studious by introducing periodical tests and proper weightage at the time of final grading.

Dr. S. S. Boral of the B.E. College has shown in his paper entitled "Role of Science in Engineering" that in the modern age science and engineering are coming very close to each other, and in doing so he has quoted Lewis Mumford. He has thus argued the case for giving greater stress in the study of science in technology. Further he has listed the particular aspects of study in the higher technological education.

Mr. P. Kundu of Jadavpur University in his paper on "Impact of Science on Engineering", traces the major milestones in the field of physics and electricity.

Mr. M. L. Das Gupta of the B.E. College has offered a large number of practical suggestions in his paper entitled "Problem of Training Engineers today in our Engineering Institutions". He has given figures of recruitment of students compared to the number of applicants, number of hours given to each student for the Bachelor's degree and the number of subjects taught in the B.E. College compared to the averages in U.S.A. and U.S.S.R.

Regarding students' indiscipline, he thinks that the leisure hours of students should be as minimum as possible and that the contact hours between the student and teacher should be increased. He also feels that aptitude tests should be taken at the time of entrance of the students. To improve the quality of teaching teachers should go abroad for study and research at intervals of 5 to 10 years. He strongly recommends the more extensive and specialised training that the Russian engineer gets today.

Principal Mr. R. Prasad of Bhagalpur School of Engineering in his paper on "Some Thoughts on Technical Education" feels that the principal shortcoming is absence of teachers in suitable numbers and with requisite qualifications. Of course some improvement has taken place in the past few years. But due to uncertainty in promotions and low pay scale etc., better quality engineers are not attracted in this field. It is Mr. Prasad's reading that today the engineering colleges and schools are attracting the best students from the science colleges and high schools. He is, therefore, of the opinion that greater stress should be given to consolidate and improve teaching at under-graduate level rather than expand post-graduate teaching and research. In any case the two together cannot be undertaken in the same institution.

Unfortunately post-graduate specialisation gets wasted as such scholars are given jobs which are entirely different from their subject of specialisation.

The teachers should visit important construction works from time to time in order to refresh their ideas.

Mr. Anil Kumar Choudhury of B.E. College in his paper "Optimum Class Size for effective Engineering Teaching" analyses his own experience in a systematic manner with regard to the effect of imparting education in various class sizes of two-or three-hour duration and also of the number of contact hours. As a result he feels that the optimum class size is 20 students per instructor for a two-hour class. Similarly the average grading is 91% in the case of 17 students per teacher for two contact hours. He therefore feels that instead of mass production of low quality engineers we should stress on trying to produce a handful of quality engineers.

Mr. B. N. Chaudhury in his paper on "Problem of Technical Education in Diploma Stage", points out that by the reorganisation of secondary schools in West Bengal there will be a large number of entrants into the Diploma courses of engineering. He feels that the shortening of the higher secondary education by

one year will weaken the educational foundation of the student and it will be difficult for them to pick up the technical subjects adequately. But upgraded schools with the technical stream would also not provide adequate technical bias because they lack a good workshop and capable teaching staff.

Mr. Chaudhuri thinks that the crucial question is of providing competent teachers only in upgraded schools and Diploma institutions. Their pay, although sanctioned to start at 350/-, is really only 250/- with a fixed D. A. Most lecturers come to it as a stop gap arrangement. At present the teaching staff is mainly composed of superannuated persons, but this is hardly a satisfactory arrangement. The scheme of training teachers for degree colleges in engineering may help relieving the need for junior lecturers but it will not secure either readers or professors with competent background of experience.

Mr. Chaudhuri thinks that too many polytechnics based on local patriotism are being set up and soon there will be unemployment among their products.

Mr. A. Guha discussing his paper on "Reorientation of Engineering Education", stresses the shortage of teachers and difficulty in procuring equipments, paritcularly in diploma institutions. In his opinion there is need for a large number of persons with engineering background but for a relatively few with highly developed technical knowledge, and the planning for educational institutions should be based on this criteria.

He feels that students desiring to take up technical education after higher secondary stage should first be admitted to a three-year course in diploma institutions. Only those who pass through a public examination after such a course should be allowed to proceed to degree institutions which should have only a two-year course. This, he feels, will eliminate a large number of failures in the degree colleges.

Principal R. N. Banerjee, Jute Technology Institute, in his paper on the "Role of Professional Institutions in the field of Engineering Education", pointed out how due to various difficulties many students cannot pursue their education in the universities and colleges. For them the Institution of Engineers provided a scope for further education in engineering through its two examinations. Many mushroom organisations have now sprung up to provide coaching to students to appear in such examinations and in the absence of proper facilities there are a large number of failures.

The Institution of Engineers has drawn up a scheme of providing part time evening courses in existing polytechnics and engineering colleges as well as through correspondence courses. But these facilities to student members can be provided only when suitable arrangement has been made for their practical training. The Institution is considering some practical steps in this direction which have been listed in the paper.

Mr. R. B. Chakravarty, Chief Engineer, Floods, West Bengal, in his paper on "Engineering Education in India" finds that the products of polytechnics do not have sufficient practical training. He also found that many engineering graduates with special training are given jobs involving work other than the subject of their specialised knowledge.

Mr. Chakravarty makes some important suggestions including the formation of one national body to control and guide engineering education, making it possible for prospective employers to remain in touch with student engineers even when they are receiving education, enabling teachers to practice as consultants, having visiting lecturers in engineering colleges and reorganising the examination system with a view to discourage cramming.

DISCUSSION

Opening the discussion of the papers **Prof. Durgadas Banerjee** of the B.E. College formulated a number of questions. He enquired, should we plan for more "contact hours" or for more "leisure to think?" Should the courses be science-based or should they be practical-based. He thought that in the context of our requirement we should try to produce not merely "creative engineers" but also "standard engineers" as also technicians and diploma-holders. It was his conviction that the teaching of history of engineering and science is vitally necessary in imparting technical education.

Mr. Mangrulkar representing the Tata Iron and Steel Co., recommended that so far the approach of the employer towards the engineers had been "whether the latter can deliver the goods". But he felt that engineering education should be science-centred. An engineering graduate is not expected to repair your fan. He, therefore, appealed to the industries to reorientate their outlook and approach in such a way that the "general product", that is, the graduate engineer, is well received and then the best is taken out of him in the course of the work, after giving him a training for the specialised job.

He felt that the Government can do something in relation to small industry. For example it can help them to take to a scheme of in-plant training.

It was his reading that there is a definite need for diploma holders in industries. But unfortunately the craze is for degrees. The diploma holder must be offered wider openings. This can be done by providing part-time education in evenings—a suggestion for the Institution of Engineers to consider. It was also his understanding that we could not simultaneously plan for research in post-graduate work as well as double the number of students in engineering institutions. With limited resources, the two policies

could not be provided for at the same time. Research should be limited to only the brilliant few.

Prof. R. N. Banerjee thought that the real problem was of finding the proper teachers. He suggested that there should be a Central Institute for training teachers. Guest professors should also be made available to the various educational institutions in adequate numbers.

Mr. Bhupal Krishna Datta wondered how there could be hundred percent first class in the results of engineering graduates. He also thought that the source of trouble may be partly due to defective raw materials, namely, the students admitted into engineering educational institutions were rather of poor quality.

Mr. S. Basu described commercialisation of educational institutions for providing cheap degrees in any numbers. These institutions have become purely examining bodies, giving less stress to imparting of education, and are handing over degrees on a mass scale. It was his feeling that education in engineering should follow practical work—practical work must be followed by theoretical work and not vice versa.

Dr. K. L. Rao, intervening in the discussion, said that geniuses are god-trained. This century is reshaping the world on entirely a new basis. The next one will outbeat us. The pace is determined by new factors, not by old standards.

It was his reading that in India the creative phase in the engineering world can be divided by the time of the erection of the Taj Mahal. That is, after 1630 A.D. not much has been achieved in this creative sense in this country. What he was trying to drive at was that we should bring back this creative spirit in the modern context again.

Prof. R. G. Hennes, Guest Professor at the B.E. College, welcomed the stress on the case-method of teaching as suggested by some. Research in colleges was not only to be for the evolution of new ideas but also for promoting thinking by students. The teacher should be paid much better than at present and should also be allowed consultation practice. In view of the complexity of technical education today, it should be more science-based. But it is easier said than done. One could say what could be *added* to the present syllabus of study but it is rather difficult to suggest what should be *cut down*, although this is also necessary. He also touched on the language question.

Prof. Van Vleet, Guest Professor at B.E. College, thought that there should be only one code of ethics for all and engineers do not need a separate one. He felt it vital that there should be more scope for continued self-education even after graduation and in this evening training courses can prove useful.

After lunch, the session started with reading of the final group of papers. Prof. H. C. Guha, Dean of the Faculty of Engineering, Jadavpur University, presided.

Mr. R. Muthuswamy of Hindustan Steel Ltd., in his paper on "Training of Engineeers and Metallurgists for Hindustan Steel" described at length the training of engineers and metallurgists for the three steel plants, in the U.S.S.R., U.S.A. and the United Kingdom and also in some of the institutes and colleges in India. He also gave an idea of the training of graduate engineers at the steel plants.

On the basis of the above experience he made a few suggestions for future guidance. Among these are: Giving of practical training in factories while students are in colleges—at least 120 days vocational training during degree course; during such training the student should be supervised by factory authorities on whose reports the merits of the student should be assessed durng their final examination. He was also of the opinion that humanities mainly concerning management and economics of construction should be imparted to these students. Industrial production engineering need also to be taught as a special course.

The paper gives a detailed idea of the requirement of engineers in the steel plants category-wise during the Third Plan.

Dr. G. De of the Jadavpur University in his well-argued paper on "Problem of Graduate Training" stresses the need for better training of the graduate in our engineering colleges. He analyses the present inadequate as well as defective arrangements for training and apprenticeship in Industries and suggests the adoption of the German system of teaching very forcefully, as this will help the Indian graduate to be competent engineer soon after he leaves his college. He lists the various requirements in the present institutions to be made available for this readjustment. The idea of establishing an Industrial Estate in the Jadavpur University, he feels, can be very useful in imparting such a kind of training.

Mr. S. Bhattacharyya of Saxby and Farmer in his paper on "Standardisation of Engineering Education" lamented the lack of uniformity and interchangeability of the products from different technical institutions and engineering colleges. He has suggested that an investigation be made into the methods of education in these various institutions under different heads such as: process of intake, syllabus, hours of study, ratio between theoretical study and laboratory work, ratio between sessional marks to total marks, etc. He pleads for standardisation under these heads on an all-India basis to avoid colossal wastage.

Professor R. M. Advani, of M.B.M. College,, had sent a brief note based on a seminar held on the subject at M.B.M. College, Jodhpur regarding "the progressive deterioration in the quality of technical personnel". In the course of this note he listed its causes

and the remedial measures. In the latter category, he suggests slowing down the pace of expansion, producing good teachers by raising their status and pay scales and improving their training, tutorial systems etc. He also suggests improving the knowledge of the English language, double shift in institutions, training during the vacation. A number of other suggestions have also been made.

Mr. S. K. Ray, Director of Personnel of the DVC, in a brief note received late, raised a few points. He felt that there is an apparent lack of confidence in our boys as they come out from the schools and colleges and this is mainly due to environmental reasons. He drew the attention to the successful experiment in England during the Second World War when trainees hostels were filled with products of their respective trades which created a sense of association in their mind.

Mr. Ray also thought that in our teaching system there is need for repeated stress on the fundamentals at all stages of education.

Students going for practical training in industry are mostly left to observe. He thought that this is inadequate and suggested the American system of handing over a questionnaire to each student by the supervisor so that the student may try to understand the mechanism of production by answering the questions.

In order to secure only those students who have a natural inclination for the profession, Mr. Ray suggested psychological tests before admisssion.

In order to enable experienced persons in particular branches of engineering not having degrees to secure this, Mr. Ray suggested the experimentation being made by the Tennessee University by arrangement with the TVA.

Discussing the papers moved by their authors, **Mr. R. B. Chakravarty** welcomed the idea of correspondence courses but he later laid great stress on more frequent periodical exercises rather than on annual or half yearly examinations.

Mr. A. K. Bhaumik, Chief Engineer, Electricity, West Bengal, referred to the need for creative engineers and suggested that the Government of India should select about 100 engineers every year and put them in a high cadre like the I.A.S. and give them no work except to make original research.

Principal A. C. Roy of the B.E. College explained by diagrams the magnificent progress made in the country in the field of technical education under extremely difficult conditions. He paid a compliment to the teachers who have indeed worked hard. He thought that the challenge of development facing the country has to be accepted in spite of all difficulties in the field of engineering education and he was confident that with greater awareness about it in the country, the teachers will succeed in their task.

RESOLUTIONS

Dr. K. L. Rao then summed up the discussion and placed before the participants in summary and tentative form the ten resolutions which were, after some discussion, adopted and a small committee consisting of Dr. T. Sen, Principal A. C. Roy, Prof. H. C. Guha, Prof. Van Vleet, Prof. R. N. Banerjee (Convener) was constituted to finalise these and to communicate the same to the Government of India and other relevant authorities.

1. It was considered desirable that at least a few months' practical training be given to students of higher secondary schools passing out from either the science or technical streams.

2. In view of the rapid development of engineering and technology the world over, more emphasis should be given to the training in fundamental sciences for the students qualifying for the engineering degree course.

3. Adequate encouragement should be given to the staff of engineering colleges for post-graduate and research activities. Extra remuneration to engineers should be in recognition of higher academic qualifications, in order to encourage post-graduate and research students.

4. Training of engineering graduates should be arranged even during the courses of study, making full use of the vacations, and they be encouraged to find out their aptitude for specialised aspects of engineering. This would help specialisation and enable absorption of graduates into industry soon after their completion of study.

5. Most senior engineers today find little time to think and study, being loaded with too much routine duties. Measures should be taken to change this state of affairs.

6. English should be taught in sufficient strength in the schools, so that engineering education could be imparted through that language effectively, till such time it is replaced by either Hindi or the regional languages.

7. Arrangements should be made to publish cheaper editions of the more popular technical books for use by students and professional engineers. Loan libraries should be opened in most important towns and industrial areas to enable engineers to borrow books on long term basis.

8. Professors in the engineering colleges should be associated with industrial projects and they should be allowed to act as consultants to industrial and engineering concerns.

9. In the interest of overall economy and to establish engineering leadership in all the engineering industries and projects, competent engineers should

[Continued on page 28]

GUIDANCE FOR AUTHORS

Normally, only original manuscripts will be accepted. No manuscript is acceptable if an appreciable portion of its subject matter is readily available elsewhere in published form. The authors are requested to note carefully the following before sending their contributions;

1. The manuscript should be typewritten on good paper of uniform size (quarto or foolscap) with *generous margins and double spacing between the lines.* The pages should be numbered consecutively, and only one side should be used.

2. The original copy of the manuscript, and not a carbon copy, must be submitted. Mathematical symbols and Greek letters should be inserted in ink clearly.

3. The length of a paper will naturally depend on its subject matter but it should be as short as the nature of the subject will allow. *Brevity is the essence of a good contribution.* There should be no undue recapitulation of well-known first principles or engineering theory and practice. The length of an article is limited to 5000 words. Papers of 5000 to 3000 words will be very acceptable. Each paper must give an *abstract (not an introduction) in about 150 words,* suitable for printing at the head of the paper.

4. Manufactured products should not be referred to by a maker's name or a trade-name unless that is unavoidable.

5. The contents of a contribution should usually be arranged as follows:

* (a) Title
(b) Table of Contents
(c) Abstract
(d) Main Text
(e) Conclusions
(f) Acknowledgments
(g) References or Bibiliography

* The title of paper should indicate briefly the main subject. When writing his name beneath the title, the author should give particulars of his professional position, or occupation and indicate his rank.

6. The contribution should be accompanied with a brief note about the author's professional and educational background, etc. on a *separate* sheet and a copy of his photograph.

7. Abbreviations and symbols should conform to accepted standards. If any phrase or word, not commonly abbreviated, is abbreviated for convenience it should be explained when first used.

8. Section headings, sub-headings and paragraphs should be inserted to divide the text into its natural parts.

9. Extended mathematical proofs, digressions and detailed explanations of methods, tests etc. should be excluded; they can be added, if necessary, in the form of appendices. Long quotations should be avoided: normally, a reference to the original publication in the text should suffice.

10. References must be complete and accurate. The details required are:—

For books and pamphlets: author(s), title, publisher, place of publication, date of edition and page number(s) if relevant.

For Journals: author(s), title of article or paper, *unabbreviated* title of the Journal, date of issue, volume, and page number(s).

11. Tabular matter should be kept to a minimum. All tables should be numbered consecutively in *Roman* numerals and should carry a clear heading. Each table should be *referred to by its number in the text.*

12. Ditto marks should not be used.

13. The number of illustrations to each paper must normally *not exceed 10 figures*—graphs or photographs. The editor, however, reserves the right not to publish any of them.

14. Photographs must show some unusual or unique features which cannot be explained concisely in words or by means of a line drawing.

15. For satisfactory reproduction, photographs must be on good glossy paper and clearly and sharply defined. Lettering on photographs is undesirable. *Negatives should not be sent.*

16. Line drawings, curves, diagrams should be drawn in bold black lines with Indian ink on white paper or card. Good black line prints may be submitted, but blue prints are useless for reproduction purposes.

17. Coloured illustrations should be avoided. Any distinction necessary in sectional drawings can be indicated by different kinds of cross-hatching, and in circuit diagrams by the use of different kinds of broken line.

18. Illustrations must not be drawn in or pasted on the text of the manuscript. The (both drawings and photographs) should be numbered consecutively throughout with *Arabic* numerals and carry a brief description on the back in pencil. Each should have a brief caption, and be referred to in the text. Where confusion may arise, pencil marking on the back is essential.

19. Reading matter on an illustration should be kept to the minimum. Reference letters may be placed on the illustration and explained with the caption notes or in the text. The captions and caption notes should preferably be collected and listed on a separate typewritten sheet. Legends and lettering, if included on illustrations, should be in large type sufficiently bold to remain legible after reduction.

20. If a scale is necessary on a plan or other drawings it should be shown graphically on the drawing; stated scales, e.g. "1 inch to the foot", will be incorrect when the drawing is reduced for publication, whereas graphic scales are reduced pro rata with the illustration.

The authors will be normally supplied with 20 copies of off-prints free of charge for their article. If more off-prints are needed, they should intimate their requirements at the time of sending their contribution.

Engineering Education in India

THE discussion and speeches at the Seminar on "Engineering Education in Eastern India" held recently in Calcutta under the Chairmanship of the eminent engineer-scholar Dr. K. L. Rao were indeed refreshing. As a matter of fact a consideration of this subject was overdue. It was apparent that both the teachers as well as practising engineers were very much concerned at the deterioration of the quality of engineers and technicians now being produced in the country. It was not surprising that there was a great deal of unanimity in the analysis of the situation as well as in terms of the approach to the problems arising from such a study. Everybody agreed that with the rapid development of industrialisation of the country, it needed a very large number of engineers and technical personnel. But it was also realised that while big strides have been taken in the production of such trained men in such a short period of time, the quality of the products is generally becoming poorer each year. Therefore all felt that in the rush for numbers we are losing quality very rapidly at a time when engineering and technology in the world is developing very fast and when we require high grade engineers most.

The main emphasis of the discussion centred round this problem—the problem of not only maintaining the pre-Independence standards of quality in teaching but also on improving on the same in terms of modern development, while rapidly expanding educational institutions in engineering and technology to meet the present needs. The terms "creative engineers" and "standard engineers" were frequently in use during discussion, Dr. Rao having coined the phrase in his presidential address. It was realised that "creative engineers" could not be manufactured by any set process of teaching and it was equally understood that "standard engineers" were required in large numbers. But the crux of the matter was that the quality of teaching at the base must improve very much to the extent that the 'standard engineers' were not purely of the stereotype sort and were able to undertake engineering tasks in full knowledge of recent developments in techniques. Side by side with this upgrading of quality among engineers in general, teaching at graduate and post-graduate levels should so improve and the atmosphere in these institutions should be so created that it might be possible for the emergence of "creative engineers" in larger numbers.

The discussion, therefore, naturally veered round the content of study and the quality of teachers. While a few still talked about "practical-centred education, most of the participants, both among teachers as well as practitioners of engineering, strongly felt that engineering education, particularly at the graduate level, should be 'science-centred' and that it should ground the students strongly on fundamentals of engineering rather than on its details. This was as a result of two aspects of thought. One was that since the Second World War science and engineering have reached new heights and the scientific revolution of the 20th century is still at its peak, thus reducing the gap between engineering (as applied science) and the fundamental sciences. Therefore a modern engineer must have a deep foundation in the major scientific subjects such as physics, chemistry and mathematics. Only then he will be able basically to keep in touch with the changes that will take place after his graduation. The other trend of thought was that the subject of engineering itself is getting more and more specialised and within these specialised subjects techniques are getting revolutionised almost overnight. Therefore, it may be that the techniques which he studied for four years might have been already anti-dated after the graduation if he contented himself in specialised study of these old techniques only. It would, therefore, be much better if the engineering student were taught the basic approaches in each subject instead of giving unnecessary stress on the details of present-day techniques. The main emphasis would thus be to provide the basic grounding in science and engineering and help the student to think out how the problems are solved, so that he may be in a position to solve newer problems on non-conventional lines if it came to that.

The practical implications of this approach in terms of syllabus, methods of grading, teaching, practical training and research are obvious. Some of these were discussed at the Seminar. It was generally agreed that the present syllabus needed to be reoriented; the pattern of examination also needed to be changed considerably so that the students did not tend to cram but to think. At the higher level considerable stress was given to the need for reseach work.

One major issue as to how to reconcile quality teaching with ever expanding class-rooms appeared to be inadequately discussed at the Seminar. Yet this

is a vital practical question which will appear in greater dimension with the years. To us it appears that the West German methods prevalent in some of their Technical Universities may better be closely studied.

But the greatest stress during the Seminar was laid on the question of providing a good quality teaching staff to these institutions. For without this all talk of improving quality would be meaningless. It is through the teachers that the transmittal of engineering knowledge to the new generation takes place. Text-books are not enough. Teachers provide a personal character that cannot be dissociated from the imparting of education, and the end product depends so much on the quality of the teachers. It is true that today working under extremely hard conditions they have contributed substantially to the large number of engineers that the country needed very much. The best of the engineers, however, have been attracted to the profession and the services. If the Government and the country are really seriously concerned with the deteriorating condition of the engineers that are being produced in the present-day institutions, and if they really desired quality engineers for the transformation of the country, then it is obvious that some serious steps have to be taken to attract more quality engineers to the teaching profession, and only then their multiplication can take place. Though pay scales have to be improved considerably, it is not only a question of monetary incentive; they have to be provided with facilities for research and for keeping themselves in close touch with the latest world literature on engineering, they have to travel and see for themselves the actual application of new techniques, etc. Quite some valuable time has been wasted by neglecting the educational aspect of the country's development. It is therefore high time that something serious be done about it if we mean business. It is a question of vital perspective planning and not of calculating immediate dividends in rupees. Some excellent suggestions have been made in this regard during the discussions, and possibly a few more may be added. But the prior thing is to impress in our minds that *the planning of the growth of skill and alert minds in the country is something qualitatively different and basic from planning an industry or material means of production.* We compliment the participants of the Seminar to have been able to hit the right nail in the matter.

All in all, the Seminar should be able to focus the major problems in the field of engineering education before all concerned. It should also be the beginning of getting the engineers and the teachers in this field closer together. (Possibly the Institution of Engineers and the Engineering Educational Institutions can initiate some concerted steps in this direction). It was therefore extremely timely that a small continuing committee has been formed with a view to press for giving practical shape to the generally accepted ideas evolved out of the discussions. Let us hope that this committee at least would not sleep on its task on which so much depends.

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Our Contributors

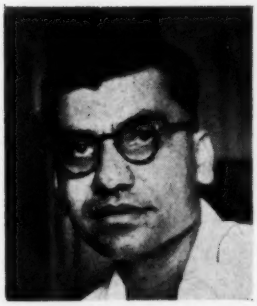
Mr. M. Hayath is chairman of the Central Water and Power Commission and has been our contributor previously, the last being in the Tenth Anniversary Number, December 1960.

Mr. S. Swayambu is Director, Research, in the Power Wing of the Central Water and Power Commission. Also a previous contributor.

Dr. A. E. Morgan is the eminent consulting engineer of America who was the first Chairman of the TVA Board and also a member of the University Grants Commission, India. He contributed an article previously in our Journal.

Dr. L. E. Benson is incharge of the Metals group of the Research Department at Metropolitan Vickers.

Mr. J. Johnson is incharge of the Metallurgical section of the Research Department in the Metropolitan Vickers. Both of them contributed an article in our issue of November, 1960 of which this is the concluding portion.



Mr. D. Mookerjea is Chief Engineer, Kosi Project; was previously in the DVC incharge of the Durgapur Barrage Project.

Dr. Ajit Mozoomdar M.Sc., D. Phil. (Oxon), Member of the Indian Administrative Service, British Council Scholar and Scholar of Nuffield College, Oxford, 1951 - 53. Additional Director and later Director of Industries, Government of Bihar, 1953 - 59. Jute Commissioner in the Ministry of Commerce and Industry, Government of India, at Calcutta, since June, 1951.

Mr. V. Rama Rao is Executive Engineer in the DVC.

Dr. H. L. Uppal, M.Sc. Ph.D., D.Sc., F.N.I., Director, Irrigation and Power Research Institute, Punjab. Known for his researches in the domain of irrigation and allied research pertaining to Hydraulics, Flood Control and River Training, Drainage, Land Reclamation, Soil Mechanics and Foundation Engineering. Joined the Irrigation Research Institute, Lahore as Assistant Rssearch Officer in 1931, was promoted as Hydraulic Officer in 1942, Deputy Director in 1946 and Director in the rank of Superintending Engineer in 1952. In appreciation of his experience and reserachec, the Punjab Government gave him the rank and status of a Chief Engineer and Head of the Department in 1960. Was awarded the Degree of Doctor of Science by the Punjab University same year.

Mr. S. R. Sehgal, M.A., C.St., Mathematical-cum-Statistical Officer, Irrigation and Power Research Institute, Punjab. Has done valuable work on subsoil water-table variation, sensitivity of sub-soil water-table to rainfall and irrigation, seepage losses through unlined canals and branches, gains and absorption losses on various rivers, intensity and frequency of floods and their peak determination by Probability Method etc. After an exceptionally brilliant career, started as a senior Lecturer in Mathematics and Statistics in 1946; joined Irrigation and Power Research Institute, Amritsar as Assistant Research Officer in 1949, promoted as Mathematical - cum - Statistical Officer in January, 1954 and continuing as such.

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Instruction Staff & Guides

Sri K. Padmanabha Pillai, B.E., C.E. (Hons.), M.I.E. (India).

Sri J. Visweswara Rao, B.E., M.Sc., M.I. Struct. E. (Lond.), F.ASCE., M.I.E. (India).

Dr. K. W. Bieger, UNESCO. Professor.

Dr. B. R. Sen, M.Sc., C.E., M.S. (Iowa), Ph.D., A.M.I.E. (India).

Dr. P. C. Varghese, B.Sc. (Engg.), M.Sc., M.E. (Harvard), Ph.D.

Sri R. K. Narasimhan, B.E., M.S. (Missouri), M. ASCE.,

Sri N. Roy, B.E., M.S. (Cal. Tech.).

Sri S. K. Mallick, B.E., A.M.I. Struct. E. (Lond).

Sri B. N. Neogy, B.Sc., B.E., M.Tech., M.S. (Iowa),

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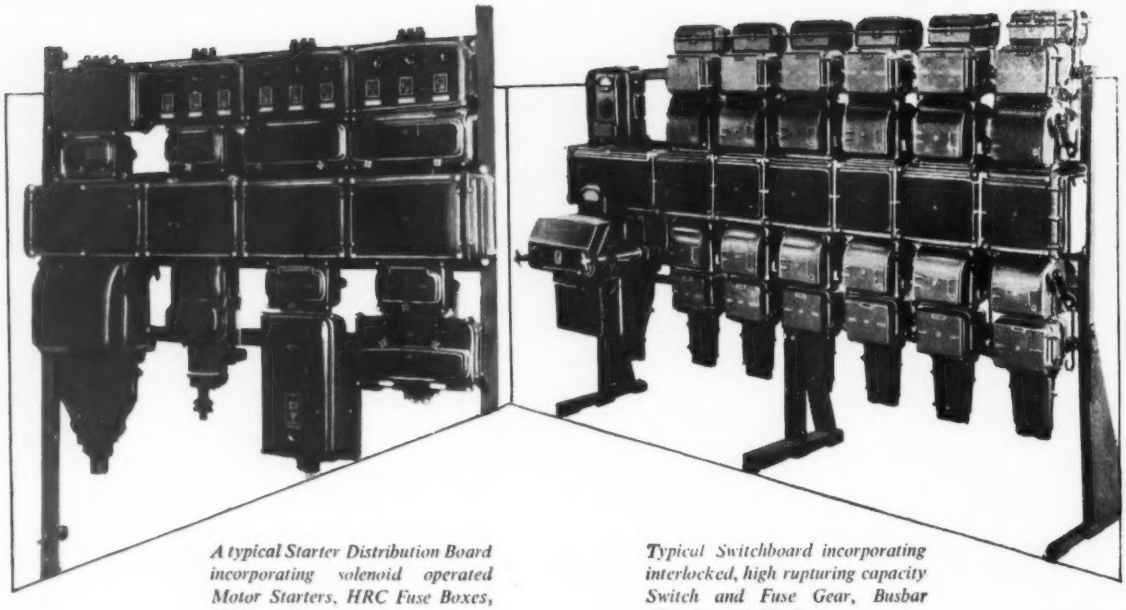

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